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EDITORIAL.

ITEMS AND NOVELTIES.

Stevens' Institute of Technology—(*Continued* from page 4).—Passing from the large lecture-hall last described, we next come to the physical laboratory, shown on the plate facing page 2 as room No. 9. Here, as in the library, the room is divided into ten alcoves, each about 18 feet square, by apparatus cases glazed on both sides, leaving also a continuous space 20 feet wide and 60 feet long in the centre of the room.

Each of the alcoves is devoted to a special class of experiments; and during the late visit of the Am. Inst. of Mining Engineers presented a scene of peculiar interest; for in each alcove some interesting experiments were constantly being performed by students of the Institute. Thus, in the first alcove, Platteau's beautiful experiment, illustrating the effect of a rotary movement upon a fluid globe deprived of weight, was repeatedly exhibited.

A large tank of plate glass, containing several gallons, was filled with a mixture of alcohol and water, in which floated indifferently a globe of oil. When the latter was made to rotate it threw off rings, which broke up into smaller globes in a manner whose beauty attracted much attention. This was the alcove devoted to the subject of Molecular Physics, and besides being provided with a Bunsen pump

and supply of water and gas, contained in its cases all the instruments for precise measurements in this subject, such as the apparatus of Simon de Metz, for accurately measuring capillary force; that of Bunsen, for diffusion, as also those of Béclard, Graham and others.

In the next alcove, under the charge of another student, was the Chronoscope of Hipp of Neuchattel, connected with an apparatus which caused it to measure the time during which a ball fell through the height of a few inches. This it did with an error, as shown by calculation and repeated experiments, of less than $\frac{1}{1000}$ of a second.

The same instrument can be readily applied to the measurement of the initial velocity of shot, or indeed, to any other phenomenon of like nature.

This is the alcove devoted to "methods of measurement," and contains, beside the Chronoscope, a Chronograph by the same maker, another by Casella; a dividing engine by Salleron, dividing 60 centimetres to millimetres; a dividing engine constructed in the Institute, dividing two feet to hundredths of an inch; a spherometer by Duboscq; a Cathetometer by Salleron; a Kater's reversion pendulum; a set of Brown & Sharp scales, gauges, squares, micrometer screws, &c.; a Saxton's Reflecting Comparator; a Comparator of yard and meter, of new form, constructed in the Coast Survey Office, under the direction of Prof. J. E. Hilgard, and provided with every refinement of adjustment; a Theodolite; a Wollaston's reflecting goniometer; a Babinet's reflecting goniometer; graduated vessels of various volumes, and divided into various measures; a Standard Balance, thirty inches beam, carrying five kilogrammes in each pan, turning with one milligramme, and sets of accurately adjusted weights for both French and English standards.

In the next alcove, likewise in charge of a student familiar with the various adjustments, were a Zentmayer Microscope, a Duboscq-Soleil Saccharimeter and Browning Spectroscope, all arranged with interesting specimens.

In the cases of this alcove, which we need hardly say is devoted to "Optics," is found a diffraction bench by Duboscq, with all its attachments of cylindrical lenses, gratings and micrometers, various lenses, prisms, mirrors, and other elements of optical construction, as well as polariscopes and polarizing objects, as likewise all the tools required in the preparation and mounting of microscopic specimens; the Zentmayer microscope, likewise including the attachments for the use of polarized light, and also the Sorby-Browning Microspectroscope.

In the next alcove was arranged the apparatus for demonstrating the law of Mariotte, and the various instruments by which the densities and tensions of gases and vapors are accurately determined. These instruments were also operated by one of the students.

In alcove No. 5 were arranged the various elaborate pieces of apparatus by which Regnault made his classical determination of the relations of tension to temperature in steam and other vapors.

This being a subject of great importance to the Mechanical Engineer, has been very well developed in the collections of the Institute, and involves many instruments in addition to those filling the cases of this alcove.

Crossing the east end of the room to the opposite alcove (No. 6), we find there the various apparatus for measurements in latent and specific heat, devised by Lavoisier and Laplace, by Clément and Desormes, by Delaroche and Bérard, Dulong and Petit, by Regnault and by others, as well as the best forms of Calorimeter.

As this class and that in alcove 5 requires much time for the execution of each experiment, these instruments were not put in operation during the visit above mentioned.

In the next alcove, however, was arranged the apparatus of Melloni and Tyndall for the study of radiant heat, and here were exhibited the polarization of heat rays, their varieties of radiation, and other related phenomena. This alcove also contained the countless forms of thermometer, which have been devised for various applications.

In alcove 8 were exhibited various interesting experiments in illustration of the laws of vibration, such as Lissajou's sound figures, obtained with tuning forks provided with mirrors, Chladni plates, longitudinal vibrations of a metal bar, and the like.

The apparatus on this subject includes as one item the entire collection on this subject of the late Charles N. Bancker, of Philadelphia, and numbers among its objects numerous sets of organ pipes and tuning forks, of every material, adapted to illustrate the various laws of sound, and also sonometers, sirens, resonators, vibrating rods of various material, Schaffgotsch's apparatus, manometric flame apparatus, Scott's phonautograph, and, in fact, an unusually complete collection of every appliance that can be made useful in the illustration or study of the subject of Acoustics.

Alcove No. 9, devoted to the subject of electrical measurement, contains a full set of measuring instruments from Elliott & Co., of

London, comprising Thomson's single coil, low resistance galvanometer, with shunts, lamp, scale, etc.: a set of resistance coils, with bridge; a tangent galvanometer, with two conical coils (modification of Gaugan's); Wheatstone's bridge; Poggendorff's rheocord; Wheatstone's rheostat; astatic galvanometer; thermo-electric pile; quadrant electrometer, with key; condenser of microfarads; spiral induction coils; differential induction coils; Dubois Reymond's induction coil. The finer instruments, such as Thompson's reflecting astatic galvanometer, are placed in a separate room, on the third floor, where they are in permanent adjustment.

Also, from Chester, of New York, a set of resistance coils, bridge and galvanometer in case, small galvanometer, commutator, &c.

The 10th and last alcove was occupied by a variety af instruments for the illustration and measurements of the pressure and flow of fluids, covering the ground of Hydrostatics, Hydrodynamics and Pneumatics.

On tables placed in the middle of the room were arranged the large Induction Coil, constructed for President Morton by Mr. E. S. Ritchie, of Boston. Another smaller coil, with some large Geissler Tubes attached, and on its own framework, a large Natterer's apparatus for liquifying gases, and an immense Delezenne's ring, for obtaining a current of electricity from the earth's magnetism.

In our next number we will carry our readers up stairs into the second floor, where are located the class lecture-rooms and *principal* cabinets of apparatus.

The St. Gothard Tunnel.—It is unofficially stated* that the contract for the construction of the tunnel has been signed between Signor Grattoni and the St. Gothard Railway Company. The conditions and prices are said to be very favorable for the Company; and this seems probable, since Signor Grattoni, having carried out the Mont Cenis Tunnel, and having all the plant and boring machinery that was used there, would naturally be in a better position than any other contractor to undertake the work at a low price, and to insure its success.

Reproducing Drawings.—M. Renault recently laid before the French Academy the following method of reproducing drawings.

The drawing is first to be made with sticky ink on highly glazed paper, and afterwards dusted with a metallic powder, (the bronze powder of commerce.) Sheets of sensitive paper, prepared for the

* The Engineer, xxxiii, 407.

purpose, are then pressed upon the former, and the lines of the drawing are reproduced upon the paper by the chemical action between the sensitive paper and the metal.

The ink upon the original may, whenever necessary, be softened by the vapor of alcohol, and the bronzing thus renewed.

A Steam Paving Tool.—A novel apparatus of this kind has lately been tried in Paris, namely, a Steam Rammer.* As used from time immemorial the rammer is a heavy iron-shod implement which the workman raises about a foot from the ground and allows to drop, as rapidly as he may, successively upon the boulders or blocks to be set. The object of the invention of M. Lignier is to save the laborer the severe physical exertion of raising the heavy tool; an exertion producing in time an injurious effect upon the lungs.

In the apparatus of M. Lignier the heavy weight is lifted by a small Lenoir gas engine. To the fly-wheel of the engine is connected the rammer of steel, smaller but heavier than the ordinary instrument. The movement of the machine is controlled by the operator; and the rapidity of the operation, according to the inventor, more than counterbalances the greater first cost.

A New Danger Signal.—An apparatus designed to inform the engineer or conductor, between the stations, of the distance between his own train and that which has preceded him—has just been put in operation on the Vermont and Massachusetts R. R.†

The signal (invented by F. S. and W. A. Foster) consists of a circle made of colored glass, red, green and white, upon which are figures plainly marked from one to fifteen, each figure denoting a minute. These figures are shown through an opening of six or eight inches in the outside covering of the glass, so that they can be readily seen by the engineer in the day-time, and at night the glass is illuminated by a lamp in the inside. The signal is operated by the train passing over the rail. As the engine passes, the signal turns back to the starting point, from the figure showing the lapse of time between the two trains, and remains stationary until the last car passes, when it commences to revolve; keeping-time six o'clock, the figures passing the opening in regular order up to fifteen; provided that the time elapses before the arrival of the next train, when the process is repeated. The invention is certainly one which is greatly needed; it

* Annales Industrielle.

† U. S. R. R. and Mining Register, xvii, No. 837.

will diminish the number of accidents upon those roads adopting it, and will render such accidents as the terrible one at Revere a year ago, simply impossible.

The Diamond Drill in Coal-Mining.—Mr. Thomas Shaw informs the editor that the Philadelphia and Reading Railroad, under the direction of one of its Chief Engineers, are engaged in sinking a coal-shaft to a depth of 1500 feet through conglomerate rock, by a process of deep boring, aided by the diamond drill, which bores a series of holes from three to four feet apart, ($1\frac{1}{4}$ in. diam.) to a depth of from 200 to 300 feet. These holes are filled with sand when completed, and three or four feet of this is scraped out, and a blast applied. The resulting rubbish is removed, and the operation of removing sand and blasting is continued until the desired depth is reached.

This process permits of a monthly progress in sinking the shaft of 85 feet, while previous operations only gave 25 feet as a result.

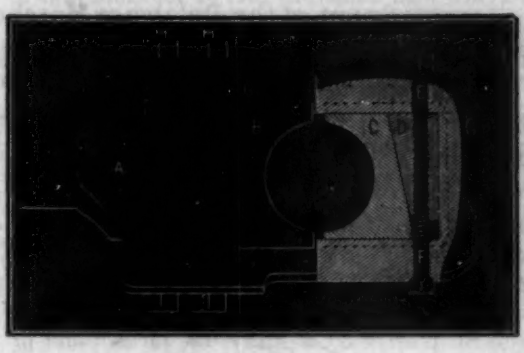
Improvement of the Delaware Marshes.—A number of gentlemen, representing the commercial, banking and manufacturing interests of Philadelphia, recently made an excursion to Delaware City for the purpose of examining the improvements inaugurated by the St. George's Marsh Company, some two miles below Delaware City, and witnessing the operation of a large Shaw Compound Propeller Pump. At the eastern terminus of the canal at Delaware City, for the distance of two or three miles south, is a tract of several thousand acres of lowlands capable of the highest state of cultivation if properly drained and kept from being overflowed by the tides and heavy rains. The St. George's Company was formed and proper steps were taken to perfectly drain the land. Sluice gates and embankments were erected, but at times the rain-falls for several miles around found an outlet through the very centre of the land to be improved.

To obviate the difficulty the company determined to bring to their aid the power of steam, though the idea was opposed by many as expensive, and not likely to effect the object desired. Eventually, one of Shaw's pumps,* the largest yet made, was ordered and put in operation about the first of the month. The pump was guaranteed to lift and discharge 25,000 gallons per minute, but at the trial on Saturday it worked up to 30,000 gallons, with an engine somewhat defective. The pump is placed four feet below high-water mark, several hundred

* For description, see this Journal, vol. lx, p. 289, or vol. lxiii, p. .

feet from the Delaware, and, though thus situated, it is capable of throwing the water against the tide. The Marsh Company seem to be fully satisfied with its operations, and are now engaged in extending the area of land to be improved.

New Forms of Stub-End.—We present two forms of stub-ends, one with a bolted strap, one solid, means of adjustment the same in both. A shows the block; B, the ordinary half-box; C, the other half, with angular back and wide flanges, to which is fitted a wedge, filling the whole space, except it is short, to allow of transverse movement, which is effected by the tap bolts E and F, the ends of which just don't touch near the centre of the wedge. It is evident that by unscrewing E and screwing F the wedge will be drawn against the box, C, and the latter made to approach the pin.



The strap C is secured to the block A by two well-fitted bolts, H H. The boxes in these stubs have square and solid backing. The whole presents a neat appearance, and will work in closer places than the gib and key stub. J. H. C.

Endless Wire-Rope Tramways.—A contemporary contains a description of the introduction of endless wire-rope tramways in our western gold and silver mining region, from which it would appear that this mode of transportation is admirably adapted to the wants of that mining region.†

It would seem that many of the valuable mines of the far west

† The Engineering and Mining Journal, Vol. xvi, 2.

are located upon the tops or sides of steep and rugged mountains. The difficulties in the way of removing the ores from the mines to the reducing works by the ordinary methods of transportation are, from the mountainous nature of the country, and the deep snows of winter, so great as to cause suspension of work in many cases for half the year, while under favorable circumstances it is very costly.

The importance, therefore, of a cheap and regular mode of transportation, under such circumstances, can hardly be over-estimated, and the necessities of the case have already called forth many inventions for accomplishing the object. But of all of them, according to our authority, the endless wire-rope tramway is destined to take the front rank. Several of them have been for some time in successful operation in Colorado, and their general introduction in other mining districts seems to be assured.

The motive power is applied at one end of the road to a "clip pulley," placed horizontally, which is a pulley furnished upon its circumference with numerous sets of movable jaws or clips, in the groove or depression of which the rope is grasped with a force dependent upon the pressure the rope exerts, and in this way prevents slipping.

At intervals of about 250 feet are placed posts, with horizontal braced beams, each of which is furnished with a bearing pulley, grooved to a depth equal to one-half the diameter of the rope. Immediately over each of these is placed another pulley with a groove equal to one-fourth the rope's diameter. The outer circumferences of the pulleys are not absolutely in contact, and space enough is left for the carriers sustaining the box of ore to pass.

Utilization of Tin Scrap.—A method of utilizing tin scrap, said to be in successful operation at several German tin plate works, is that of Mr. Adolph Ott, of New York. The scraps are placed in large perforated copper vessels, and rotated from 30 to 50 minutes in a tank containing warm hydrochloric acid, when the tin, lead, and about 5 per cent. of iron will be dissolved. The copper drum is then lifted from the acid into a vessel of water, into one of alkali, and again into water, when the scrap is free from tin and may be sent to the puddling furnace.

From the solution obtained the lead may be separated by the addition of sulphuric acid, and the tin may be obtained in the metallic state by immersing in the liquid, plates of zinc. Thus obtained, it requires only washing in water to be ready for melting and casting into blocks.

The solution left behind after the separation of the tin, containing chiefly chloride of zinc and iron, it is said is found serviceable in preserving timber by impregnation.

The immense heaps of scraps which very shortly accumulate about the neighborhood of tin plate workers is as much of a nuisance in its way as the unsightly slag heaps which often hide the iron furnaces. The material is too valuable to be wasted, but thus far all processes for its utilization have been either too expensive or roundabout, or at best indifferently successful. Should it prove otherwise with the one described above, it will prove of as much service to the manufacturer as to the inventor.

Converting Wrought-Iron into Steel.—A process of manufacturing axes, hammers and other implements by first making them of wrought-iron and converting this into steel, has recently been patented by Mr. Viger, of Montreal.

The inventor describes the essential portions of his process as follows: "The nature of the invention consists in manufacturing the articles to be treated of wrought-iron first, and immersing them in a bath of molten cast-iron, free from sulphur and phosphorus and carburized to its utmost capacity. The best for this purpose is spiegeleisen, but in default thereof such cast-iron may be made by melting good malleable iron or blister steel in a cupola furnace with charcoal or other pure fuel. The articles are left in this bath a space of time which must vary with the degree of hardness to be imparted to the metal, and with the size of the articles, and also according to the intention of converting the whole mass of the metal into steel, or simply of converting the surface, so as to retain a core of malleable iron."

As after a number of operations the cast-iron bath would become deprived of a quantity of carbon, and as in this case the temperature required to keep it in a state of fluidity would be great enough to fuse the external carburized portions of the articles before the underlying layers are acted upon, the inventor designs to meet this difficulty by lining the crucibles and the bottoms of the furnaces with a brasque of charcoal powder or of plumbago, into which he incorporates pulverized horn, leather, or nitrogenous matters such as cyanides.

The Use of Sulpuretted Hydrogen as a Blow-pipe Reagent.—Mr. J. Landauer has communicated to the Chemical Society

of Berlin the fact that it is perfectly feasible to obtain all the characteristic sulphide precipitations usually obtained in the wet way, by simply mixing the metallic compound to be tested with powdered hyposulphite of soda, and bringing the same upon a borax bead into the reducing portion of a blow-pipe flame. In order to avoid the difficulty resulting from the ready volatility of certain compounds, like those of mercury and arsenic, and the ambiguous colors of others, the author recommends the mixture to be placed in a small glass tube, and to be heated therein. After the reaction, which can readily be followed by the smell of the sulphuretted hydrogen evolved, the fused mass will possess the sulphide colorations most clearly. It is also recommended that the hyposulphite be made anhydrous before use.

The Use of Bromine in Analytical Chemistry.—In a former number of the Journal, we took occasion to notice the recommendation of Mr. Kämmerer, who placed a very high value upon bromine as a substitute for chlorine in analysis. Since that time, to judge from several publications upon the subject, it appears to be steadily growing in favor with chemists. Mr. P. Waage* is the last of the writers on the subject, and, as the result of his experiments, declares bromine (in aqueous or hydrochloric acid solution) to be in every respect more suitable as an oxidizing agent than either nitric acid, chlorate of potassa and hydrochloric acid, or chlorine. Each of the last-named reagents, while possessing certain advantages, have certain drawbacks which place a limit to their usefulness. Nitric acid, the usual oxidizing agent, will only be of service when concentrated, and when in this state cannot be used in platinum vessels on account of the small quantities of chlorine which it generally contains, and must be kept from contact with organic matter like filter paper, if subsequent precipitations are to be made. Chlorate of potassa will only act when in presence of somewhat concentrated hydrochloric acid, and a difficulty is always experienced in drawing out the last portions of chlorine, which necessitates at times repeated addition of hydrochloric acid. The use of chlorine is attended with the objection of the arrangement of an apparatus for every oxidation, and the fact that only a small quantity of the gas can be dissolved in water, rendering the employment of much liquid necessary. Bromine, however, seems te be free from these drawbacks, and hence to be deserving of a place as a standard oxidizing reagent in the analytical laboratory.

* Chem. News, xxv, 282.

The author recommends its employment, either pure or as bromine water (which can be obtained with two to three per cent. of bromine), or in hydrochloric acid solution, containing about 18 per cent. of bromine. The color of the element is a good indicator by which excess may be avoided, and its low boiling point permits it to be driven off with little difficulty. Bromine water is without action on platinum (except in presence of nitric acid), and is without action on filter paper. As an agent for the oxidation of sulphur, sulphydric acid and metallic sulphides, as in the solution of iron or copper pyrites, mispickel, and precipitated sulphides, the opinions of those who have worked with it, express nothing but the most complete satisfaction.

A Circular for Furnace Makers and others.—We have been requested to give publicity to the following circular:

NEW YORK, 119 E. 12th St., June, 1872.

DEAR SIR:—Having the intention to publish a book on American inventions for heating apartments and dwellings, viz.: stoves, hot air furnaces, hot water apparatus, steam heaters and radiators, you would oblige me by sending me at your earliest convenience illustrations with specific descriptions of your stoves, furnaces or other contrivances.

Representations of all the various inventions will, of course, be given, but, as they will have to be executed uniformly, I beg to dispense for the present with the sending of any wood-cuts or electrotypes.

In order that you may be able to insert the latest improvements you may bring out, I will notify you when the manuscript is ready to be sent to press.

Relying upon your kind concurrence in this matter, and assuring you of my best attention to your communications,

I remain very respectfully,

ADOLPH OTT.

A new work, giving to the manufacturer and the public descriptions of the latest improvements in this brauch of industry, would be very desirable as well as useful. Mr. Ott is well known in scientific circles as an investigator and frequent contributor to various scientific journals, and believing that the work he proposes to undertake will be well done if done at all, we cheerfully call attention to his circular.

The Steam Jet for Exhausting Air, &c.—In our last issue a brief description was given of a paper read before one of the English Mechanical Associations, by Mr. Siemens, describing a new form of steam jet, which the author claimed to be the most suitable for practical application in the arts. Several such possible applications were suggested in the paper, and referred to in our notice, viz., in the exhaustion of the pneumatic dispatch tubes for transmitting

telegrams or mail parcels; in aiding the evaporation of the liquids of the evaporating pans in sugar refineries; in pumping water by a peculiar mechanical arrangement for the purpose, &c.

Our attention has recently been called to an article published by Prof. John C. Draper, in the London *Philosophical Magazine* for May, 1870, and more recently referred to in the *Scientific American*, in which the same principle is described and illustrated in its application to filtration in the laboratory, in refineries and manufactories. In justice to Prof. D., his claim to priority in the form of his apparatus, and especially in the suggested applications, would seem to be clearly made out. An illustration of this device is herewith given, which shows a stout boiler, A, furnished with a pressure gauge, B, an adjustable supply funnel, C, and a tube, D, connecting with the exhausting arrangement, or steam vacuum tube, E, represented in section at F. In this, F is a brass or glass tube, one-half inch in diam., terminating in a small conical nozzle one-thirty-second of an inch in diam. A second tube, G, passes through the stuffing-box, H, into the interior of F. At K, another one-fourth inch tube enters F. A simple filtering apparatus is represented in connection with the vacuum tube. With the generation of steam in boiler, A, the action of the apparatus is apparent. But with so extremely useful a mechanical principle, susceptible of such various applications and under so many and various forms, it seems to us that any claim for originality in first suggesting its use will be extremely difficult to sustain; a statement of which we have a direct illustration at hand.

Mr. Siemens, we believe, only claims as his own the *form* of the

jet, stating especially that, though the principle has long been known to mechanical engineers and others, and frequent attempts had been made to give it practical application, yet much difficulty was experienced, and the use of the various forms of the jet rendered comparatively worthless, from the disturbing currents and eddies always produced by the blast, greatly diminishing the exhausting action. He therefore recommends an annular opening for the steam passage. By reference to the article of Mr. Coleman Sellers, on Tilghman's process of cutting hard substances,* it will be seen that almost identically the same design had been adopted as the best by Mr. Tilghman in experimenting to bring his remarkable invention to practical realization, months before it was proposed by Mr. Siemens in England.

The same principle, *i.e.*, the exhausting and propelling action of a steam jet, has received practical application for years in the smoke-stack of the locomotive, in the Giffard injector, and in various forms of water-heaters and condensers.

New Uses for Color-Changing Substances.—Some months since we recorded in the Journal the discovery, by Meusel, of certain double iodides, which possessed the curious property of changing color very readily upon the application of comparatively little heat.

The discovery of these sensitive substances, and the character of the changes they displayed, at once attracted attention of physicists, and called forth several investigations, in which a large number of substances were examined, with the result that nearly all substances, when properly experimented with, show a similar sensitiveness, though in general far less marked, than that of the newly discovered iodides.

The same discovery has lately furnished the material for fresh investigations which have afforded important results in determining with great accuracy certain somewhat abstruse physical problems, and has at the same time afforded a practical suggestion, which we are sure will not be lost, but sooner or later will receive actual application in machine practice.

Our reference is to an interesting investigation of Prof. A. M. Mayer,† in which he employs one of these iodides, (that of copper and mercury; prepared by adding to a warm solution of mercuric iodide in potassium iodide, copper sulphate, and then sulphurous acid,) for obtaining a precise method of tracing the progress, and of determining the boundary of a wave of conducted heat; a question of much interest in the higher departments of physics.

* See this Journal, Vol. lxi, p. 195.

† Am. Jour. of Science, iv, 37.

The article concludes with the suggestion that a more useful application may be made of this, or of several other sensitive compounds, by painting them on the *pillow-blocks*, and other parts of machines, which are liable to injurious heating from friction. As the iodide in question changes within the limits of the freezing and boiling point of water, from a brilliant carmine red to a brown-black, becoming regularly darker with each additional increment of heat applied—the thoroughly practical character of the suggestion becomes apparent. There would be little difficulty in accurately gauging the amount of color-change for different temperatures, and in recording the corresponding tint, where great accuracy were needed; while ordinarily, optical inspection would be sufficient to show the operator the temperature of the moving parts of his machines, often inaccessible to any other mode of observation.

Oxidation of Sulphur by Ozone.—Prof. A. W. Wright† has made the observation in using the Holtz Electrical Machine, that the ebonite insulators generally employed in this form of machine, frequently becomes covered in warm weather with a moisture possessing an acid taste and reaction, and which proved upon examination to contain sulphuric acid. The difficulty of using the machine at times must now be ascribed partly to the presence of this substance, which exalts very considerably the electrical conductivity of the hygroscopic moisture always present on the insulators. Further examination proved that the acid originated from the action of the ozone on the ebonite insulators, slowly attacking them and oxidizing the liberated sulphur. Experiments made with a view to determine whether sulphur could be directly oxidized by ozone were unsuccessful.

The Solvent Action of Liquid Ammonia.—Mr. G. Gare has taken up the subject of the solvent action of liquid ammonia, first discovered and investigated by Prof. Seely, of New York, and has enlarged the interesting observations of the last named chemist by the examination of some 250 substances. He announces the alkaline metals (Seely), iodine, bromine, sulphur and phosphorus to be soluble to a greater or less extent. Many inorganic salts swell up without dissolving.

The Solubility of Ozone in Water.—L. Carius has made the observation that ozone is, under proper conditions, appreciably absorbed by water, which fact he has communicated to the Chemical

† Am. Jour. of Science, iv, 29.

Society of Berlin. He recommends for the purpose that the water shall be near its freezing point, and that the vessel containing it shall have but a small neck. If these conditions are observed, and a stream of ozonized oxygen is conducted into it, the water will take on gradually the characteristic smell of ozone, and its presence may afterwards be proven by all the usual reagents.

The method of preparing the gas followed by the author was that of Soret, namely, by the electrolysis of cooled diluted sulphuric acid, using platin-iridium poles.

The ozone solution so prepared may be brought upon the lecture table, and used to bring about all the oxidizing experiments usually performed with the gas itself. Several analyses made by the author, gave the amount of the absorbed ozone at very nearly one half per cent. by volume.

Editorial Correspondence.

Steam Boilers.

Editor Journal of the Franklin Institute:

Dear Sir:—The evaporative capacity of a boiler is measured by the number of pounds of water converted into steam by each unit pound of coal; the density of the steam formed will be practically unimportant, if, as we are informed, one pound of coal will evaporate the same weight of water at all temperatures and pressures.

The quantity of water passed through a boiler is not necessarily the measurement of its evaporation, as the steam invariably carries with it minute particles of water; an excessive quantity constituting the phenomenon known as priming, the true evaporation effected by a boiler, can only be determined by deducting from the apparent evaporation the weight of water passing through it unevaporated. The importance of attending to this not generally recognized fact, cannot be better illustrated than by showing that, if the evaporative quality of a boiler were determined by the amount of water passed through it, in a given time, by a certain amount of fuel, the boiler most defective in design, *i. e.*, cramped in its steam room and water passages, and without proper means of circulation, would come out the best, whilst the notorious primer would stand at the head of the list.

It is not uncommon, in these days of patent boilers, for their proprietors to claim for them an evaporation of from 12 to 18 pounds of water per pound of coal consumed. That they are enabled to dis-

perse this amount of water, only proves the boilers to be very bad ones, from the causes pointed out above. Unfortunately for them, no fuel can be obtained richer than pure carbon, and it has been ascertained that one pound of this, burned in such manner that the entire heat developed shall be concentrated upon the water to be evaporated, will only evaporate about 15 pounds of water; whilst, with coal of average quality, the usual evaporation is only about one-half of this, or 7·5 pounds. As a corroboration of this statement, we append the actual evaporation obtained in the competitive trials of four of the most notable boilers, tested at the fair of the American Institute in November, 1872.

Root,	7·34	pounds of water evaporated per pound of coal.				
Allen,	7·38	"	"	"	"	"
Phleger,	7·07	"	"	"	"	"
Lowe,	7·20	"	"	"	"	"
Average,	7·25	"	"	"	"	"

The analysis of the coal used shows it to have contained 91 per cent. of carbon, which stamps the coal as first quality.

The general disposition to encourage the introduction of "sectional boilers," at the present time, will not be without instruction. We will most likely learn from it that the fact of a boiler possessing a rapid steaming capacity, is by no means an evidence of its economy in fuel. Rapid combustion is known to be more economic of time, while slow combustion is invariably the agent governing the economy of fuel. Rapid steam generation is produced by directing the intensity of the heated products of combustion to thin sheets, or multitubular divisions of water within confined limits. Every advantage is taken to interpose as little metal as possible between the heat of the furnace and the water to be evaporated, so that the transmission of the one to the other shall not be unduly hindered. The only advantage of this is economy in time; the heat will be transmitted in any case, if not in that time, then in some other. The question of rapidity of absorption, conduction and dissemination of the heat simply depends upon the nature of the material used and its thickness. The relative evaporating power of iron, brass and copper, for instance, is 100, 125 and 156. The lazy, slumbering and unpretentious way in which the Cornish boiler renders results, not yet beaten by any of our young fast boilers, is a marvel of endurance and economy.

WILLIAM M. HENDERSON.

Philadelphia, June 17, 1872.

Civil and Mechanical Engineering.

CONCLUDING REPORT OF THE COMMITTEE OF THE FRANKLIN INSTITUTE ON THE MODE OF DETERMINING THE HORSE-POWER OF STEAM-BOILERS.

Introductory.

In the preliminary report furnished by the Committee in last June, they confined themselves to the definition of the term Horse-power, as applied to steam-boilers, and to the general conditions which should be observed in any trial having for its object the ascertaining of the horse-power developed.

This report was forwarded to and read by a large number of experienced engineers and boiler-makers in the United States and England, who coincided thoroughly with the statement therein expressed, viz., that when the term horse-power is applied to the steam boiler, it signifies the evaporation of a cubic foot of water from and at 212 degrees under the usual conditions of practice, and with an average amount of economy per lb. of combustible common to boilers of that class, which in our previous report was assumed at 9 lbs. for stationary boilers.

They all deprecate the practice of estimating the horse-power of the boiler from the work done by the engine attached.

At the same time it would be perfectly satisfactory for any seller or purchaser of steam-boilers to stipulate for an evaporative capacity of a given number of cubic feet or pounds of water per hour, with an economy of so many pounds of water per pound of combustible.

Either course affords a basis of comparison and a definite amount of power to be supplied, and in justice to the public one or the other mode should be adopted, or the term horse-power abandoned in the sale of boilers.

It was the intention of the Committee, before concluding their report, to furnish some data concerning the number of square feet of heating-surface required per horse-power on various types of boilers. In order to obtain these, they forwarded their preliminary report to many engineers and engine-builders in large practice. The replies received indicate that very little has been done with that end in view,

and consequently the results obtained are defective from the omission of some important data in the trial. Mr. R. B. Longridge, of Manchester, England, who has had a large experience in this line, says, under date of October 9th, 1871, that "no experiments have ever been made in this country sufficiently complete to enable any one to solve the question submitted to the Committee."

Since the above was written, we have the pleasure of reporting that the Managers of the Fair of the American Institute, New York, have tested four boilers submitted for competitive examination, in the most thorough and scientific manner. We believe this is the only trial on record in which the quality of the steam, or, in other words, the amount of heat transmitted to the water evaporated, was made the subject of investigation. We regard this as but the commencement of a series of experiments which will have as their object the material improvement of boilers, and give them that prominence and proper share in the economic production of power, heretofore given almost exclusively to the steam-engine.

The summary of the report, which we give elsewhere, shows the *comparative* evaporative efficiency of the said boilers when new and well managed.

Whilst we have been able to collect little that is reliable and conclusive, we do not ignore the vast amount of experiments which have been made incidentally for other objects (such as to establish the economic values of coals, &c.), and we append hereto some of the results obtained in trials of stationary, marine and portable engine-boilers.

Stationary Boilers.—Report of R. B. Longridge.

We have received from Robert B. Longridge, Chief Engineer of the Manchester (England) Boiler Insurance Company, a pamphlet on the relative economy and durability of stationary steam-boilers. It contains the substance of a paper read before the Institution of Mechanical Engineers, at Leeds, Sept., 1859, and from which we make some interesting extracts.

The cuts following show the type of boiler experimented upon, and the Table IV which follows gives the heating-surface. This is calculated by omitting the under side of internal flues and tubes, as being unavailable. It is important to notice this in comparing the heating-surface of different boilers, otherwise there may appear a great discrepancy in the heating-surface required. For instance, in the multitubular boiler, under Fig. 14, the heating-surface given as 5·8 sq. ft.

ECONOMY &c. OF STEAM BOILERS.

Fig. 1. *Cylindrical Boiler with Two Flues.*

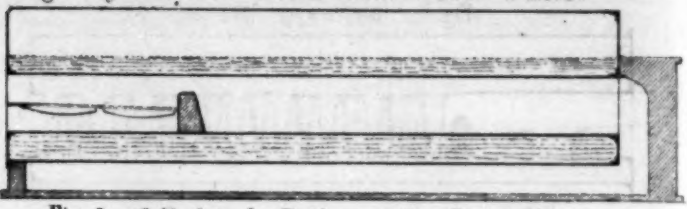


Fig. 3. *Cylindrical Boiler with Five Flues.*

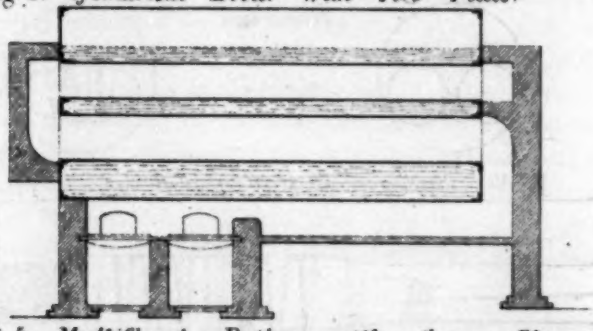
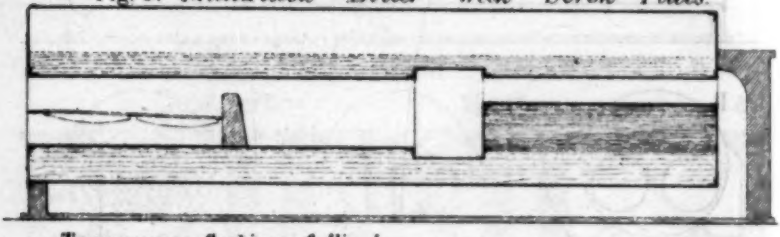


Fig. 5. *Multiflued Boiler with Seven Flues.*



Transverse Section of Fig. 1.

Fig. 2.

Transverse Section of Fig. 5.

Fig. 6.

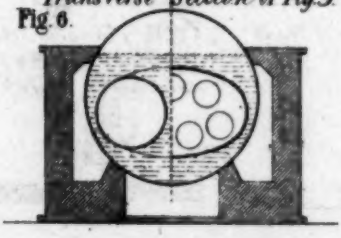
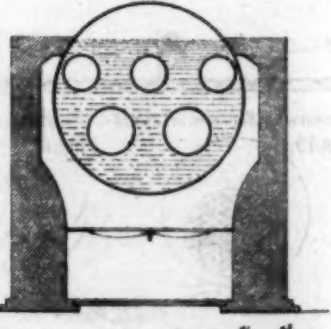


Fig. 4.
Transverse Section of Fig. 3



(Proceedings Inst. M.E. 1859 Page 147.)

Scale 1/100th.

Photo-Xincography by F. A. Wenderoth, 933 Arch Street, Philadelphia.

Print by J. H. Camp, 610 Jayne Street, Philad.

ECONOMY &c. OF STEAM BOILERS.

Fig. 7 *Galloway Boiler.*

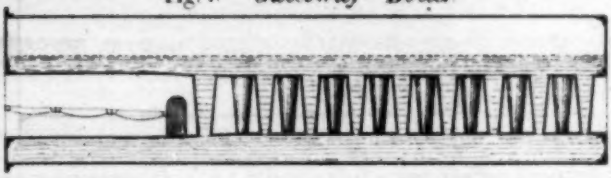
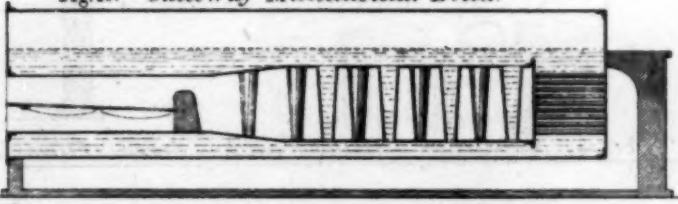


Fig. 8.

Transverse Sections of Fig 7.

Fig. 9

Fig. 10. *Galloway Multitubular Boiler.*



Transverse Sections of Fig. 10.

Fig. 11.

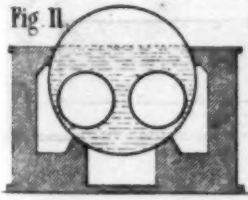


Fig. 12.

Fig. 13.

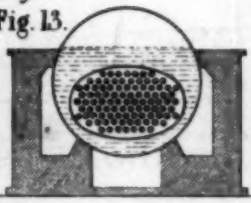
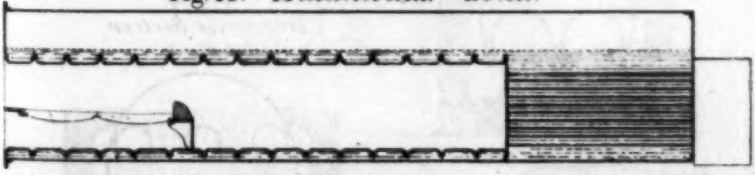


Fig. 14. *Multitubular Boiler.*



Transverse Section of Fig 14.
Fig. 15.

End Elevation of Fig. 14.
Fig. 16.

Fig. 17. *Flanged Joint of Flue in Fig. 14. enlarged. Scale 1/5 In.*

Scale 1/100 In.

(Proceedings Inst. M.E. 1859. Page 147.)

Photo-Zincography by F. A. Wenderoth, 933 Arch Street, Philadelphia. Print by J. H. Camp, 610 Jayne Street, Philada.

TABLE IV.

TABLE IV.

Boiler experimented upon.	Dimensions of Boiler.		Area of Fire Grate.	Area of Heating Surface.						Pounds of water evaporated per hour from and at 212°. Table III.	Sq. ft. required in the actual experiment to evaporate 1 cubic foot. Tables III and IV.	Evaporation of water per lb. of coal from and at 212°. Table III.	Estimated sq. ft. of heating surface required, based upon an evaporation of 9 lbs. of water.	Fuel consumed per sq. ft. of grate, per hour.
				In Furnaces.		In Flues.			Total Area.					
	Length.	Diameter.		Concave.	Convex.	Concave.	Convex.	Vertical.						
Fig.	Ft. In.	Ft. In.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.			lbs.		
1	28.	8. 6	38	90		207	280	13	590	4833	7·3	7·02	9·3	18·1
"	28.	7. 6	35	84		194	250	12	540	4921	6·5	6·86	8·5	20·5
"	26.	6. 6	30	72		154	227	10	463	3057	9·	8·61	9·4	11·8
3	18.	8. 3	30		98	252	157	23	530	4347	7·3	7·09	9·2	20·4
5	29. 6	7. 6	52	110		220	324	43	697	5714	7·3	8·53	7·7	12·9
7	22.	7. 2	30	70		93	241	95	499	4338	6·9	8·47	7·3	17·1
"	30.	7.	38½	88		288	315	207	898	7656	7.	8·35	7·5	23·2
10	26.	6. 6	30	72		230	227	70	599	3296	10·9	9 24	10·6	11·9
14	30.	6. 6	30	64		380		10	454	4329	6·2	9·62	5·8	15·—

Average, 8·8.

Fig. 1, Cylinder boilers, with 2 flues; Fig. 3, Cylindrical, with 5 flues; Fig. 5, Multiflued, with 7 flues; Fig. 7, Galloway; Fig. 10, Galloway Multitubular; Fig. 14, Multitubular.

per h.-p., would be over 10 sq. feet if all the tube surface had been included.

We make the following extracts from the pamphlet referred to:

In Table IV the several kinds or positions of heating surface are distinguished not only as furnaces and flue surfaces, but also as convex, concave and vertical surfaces; for the value of any surface must depend much upon the position relative to the source of heat, the direction of the gases from the furnace, and the degree of circulation of the water in the boiler, or, in other words, upon the more or less favorable position of the surface for receiving or taking up the heat, and on the facility with which the heat is communicated by means of the circulation of the water. In the internal flues or tubes of boilers, the deposit of dust and ashes from the fuel greatly retards the transmission of heat through the plates. On this account, and from the unfavorable position of the lower half of cylindrical flues, and also of horizontal surfaces forming the under side of flues or combustion chambers, it has been usual to exclude these in estimating the area of heating surface, as is the case in the areas given in Table IV. From the frequent fracture of plates in these parts, however, in consequence of overheating, it is evident that these surfaces do absorb and accumulate heat in sufficient amount to cause damage to the metal. By proper circulation of water this might be prevented and steam generated, though possibly not to any practically useful extent. Upper horizontal surfaces, such as the crowns of square fireboxes and combustion chambers, have hitherto been generally considered the most effective.

This seems, however, to be exceedingly questionable, particularly with regard to horizontal surfaces of large extent; for a surface can only be relatively effective in proportion to the rapidity with which the communicated heat can be carried off by the water; and the maximum of efficiency will be attained when no accumulation of heat takes place in the plates, which must depend entirely on the circulation of the water. There can be no question that horizontal surfaces are the best to absorb heat; but unless the heat be carried off by the water, and prevented from accumulating in the plates, the practical value of the surface for generating steam will be much impaired and the plates speedily injured; hence those surfaces are to be preferred, which, combined with naturally good positions for absorbing heat, offer also the greatest facilities for circulation of the water. Since, in the case of horizontal surfaces, particularly of large extent, the currents of water tending towards the middle from the outside or from above, can reach the middle only by opposing the ascending currents of steam and water, they must of necessity be more or less diverted from their course; and the circulation being thus interrupted, not only will the generation of steam be less than the surfaces are capable of producing, but as a necessary and more serious consequence, the plates must be subjected to constant over-heating, and sooner or later will become deformed and seriously injured. Under these circumstances an accumulation of deposit usually takes place, which has been assigned as the cause of the injuries and fractures of the plates, where these have occurred; though in reality the presence of deposit affords evidence only of comparative quiescence or imperfect circulation of the

water at these parts, of which it is the effect. On this account, therefore, upper horizontal surfaces, especially when of large extent, cannot be the most effective, nor even as effective, as has generally been supposed; indeed, when exposed to the direct action of the fire, they are in many cases objectionable. Surfaces concave towards the fire and heated gases, and flat surfaces deviating somewhat from the perpendicular, are probably the most effective; for from these the steam will rise freely, and the water will be brought more readily in contact with the plates, the surface being in a position more favorable for circulation; provided only that the water spaces are not too confined, a fault to be found frequently in locomotive and marine boilers. These remarks will suffice to explain the writer's object in making a distinction in the kinds of heating surface in the boilers experimented upon; and he would express a hope that this important question may be made the subject of further investigation.

There is no doubt that great as has been the progress of late years in the construction of steam engines and the economical use of steam by working expansively, this has not been accompanied by equal progress in the construction of steam boilers; for whatever may be the scientific knowledge in the latter branch of engineering, it certainly is not favorably exhibited in the generality of boilers in present use. On the contrary, the laws of combustion and evaporation seem generally to have been almost entirely ignored, and waste of fuel and rapid deterioration of boilers have been the natural consequences. In concluding these remarks, the writer would express a hope that, imperfectly as this subject has been treated, sufficient has been said to show the necessity of further investigation, and to induce other members of the institution to prosecute these inquiries, which cannot fail to prove of great practical value to the manufacturing community.

Mr. B. Goodfellow observed that in making comparative trials of the evaporative capabilities of boilers, particular care was requisite to ascertain the quantity of water actually evaporated, free from any loss of water by other causes; as well as to insure exact correspondence in the circumstances of the boilers, not only as to quality of fuel, but also to have the same draught and the same management of the fire. It was very difficult on this account to arrive at the true result; and he had known some double-flue boilers that appeared to be giving much less evaporative duty than others, although similar in construction.

The Chairman remarked that the only true comparison of the efficiency of boilers was the measurement of the water actually evaporated with the same fuel; and no correct data could be obtained from the comparison of the indicated horse-power that was often made for the purpose, since in that case the boiler and engine were coupled together, and the effective value of neither of them could be ascertained; for it might be a good boiler coupled to a bad engine or the reverse, and the results obtained were unavoidably more or less fallacious from that circumstance. The object to be aimed at was to obtain the form of boiler that best combined the advantages of economy in consumption of fuel with durability, and economy in repairs, and compactness of the space occupied; the latter points were of great importance in marine boilers and many cases of stationary engines.

From Messrs. Eastons and Anderson, of London, England, we have received interesting information relating to their practice of estimating the heating surface of Cornish boilers.

This is to calculate the area of the under side of the shell exposed to heat, the top half of the flues, and six-tenths of the total area of the tubes; and allow twelve feet of such heating surface to evaporate a cubic foot of water from 62 to 212°; this would require 10.4 square feet to evaporate the same from and at 212°—or more if the *total* tube surface were estimated.

An example is given by them of an experiment with a double flue Cornish multitubular boiler 6′.6″ dia., 20 feet 1½ in. long, with two flues 2′.6″ × 14′.6¼″ long. Number of tubes in each flue 87; 3″ diam., 5′.7¼″ long. Length of grate six feet. The boiler was fired internally, the gases passing through the flues and tubes, and returning on each side to the front end, and back again under the centre to the chimney at the rear.

Heating surface of boiler—

Shell exposed to heat, . . .	210 sq. feet.
Flue " "	165 " "
Tube surface 310 sq. ft. × $\frac{6}{10}$, . .	186 " "
	561 sq. feet.

Evaporation per hour from and at 212°, 53′.6 cubic feet.

Actual water evaporated per lb of coal from 101° to 212°, 8.78; from and at 212°, 9.8, estimated. Coal burnt per sq. foot of grate 11.2 lb.

Coals, light burning Newcastle. Height of chimney above fire 95 feet. Feed water heated to 101° by exhaust steam from Donkey pump.

Pressure of steam 40 to 46 lbs. Temperature of gases in smoke box at the end of 3″ tubes 950°; at the end of flues 670° Fah.

561 ÷ 53.6 equals 10.5 sq. feet, nearly, of heating surface to evaporate a cubic foot per hour from and at 212°, with an economy of 9.8 lbs. water evaporated per lb. of coal.

Estimated amount required to evaporate a cubic foot of water per hour from and at 212°, based on an economy of 9 lbs. of water per lb. of coal, (as per preliminary report of the committee,) 9.5 sq. feet.

If, instead of six-tenths of the tube surface we calculate the total tube surface as effective, we should require 11.7 instead of 9.5 sq. ft.

We have also received from the same firm the report of the Royal

Agricultural Society, to which they are Consulting Engineers, and from which report we make interesting extracts relating to the trials of Traction Engines, at Wolverhampton, in 1871.

The following is a general description of the Boilers tried:

No. 1. Aveling and Porter's Locomotive Boiler, 53 tubes 2½ external diam. Collective area 169½ feet, which, with the fire-box, makes a total of 204⅜.

No. 2. Locomotive Boiler by the same maker; containing 28 tubes, 2½ inches outside diam.

No. 3, By the same maker, is precisely similar to No. 2.

No. 4. Locomotive Engine with 33 2¼ inch (outside diam.) tubes, by Charles Burrell.

No. 5. Tuxford and Sons, Locomotive Boiler. Heating surface of fire-box, 21.41 sq. feet; surface of tubes, 132.75 feet.

No. 6. Howard's Safety Boiler. This boiler is of the horizontal water-tube type; the interior tubes being 9 inches in diam; the side-tubes, which touch each other, are 6 inches in diam. The ends are connected with upright D-shaped tubes. Total heating surface, taking only, as regards the two outside rows of tubes, their semi-circumference towards the fire, 276 feet; of which, probably, 184 may be taken as boiling surface, and 92 feet as super-heating surface.

No. 7. By Ranson, Sims and Head, is called a "Pot Boiler." We will briefly describe it. It consists of a plain vertical cylinder, containing at its lower end an internal cylinder of lesser diameter, forming the fire-box; there is a circular opening about 1 ft. 1½ in. diameter, to which is jointed the neck of the copper pot. Below the neck the pot swells out into a spherical form, and is of such a size as nearly to fill the fire-box; leaving, however, a space of about 1½ inch all round between itself and the inside of the fire-box. Up this space the products of combustion pass; and they make their escape from the fire-box through 36 vertical tubes, 1⅝ inch bore, 3 feet 10½ inches in length, which are inserted in the crown plate of the fire-box in the space left between its sides and the neck of the pot. The grate area is 5.25 square feet. Heating surface up to the water line 80.5 feet. Super-heating surface 46 feet. Total, 126.5.

No. 8. Pot Boiler by Chas. Burrell. Heating surface up to water line, 85.5 feet. Super-heating surface, 35.2 feet.

In the table annexed, referring to the performance of these boilers, we conclude that the *total* area of the tube surface was reckoned. We

have here based the evaporative duty of the boilers at 8 lbs. of water, instead of 9, as in the use to which these boilers were applied, that of traction engines, it is of as much importance to have a light engine as a very economical one.

Catalogue number.	Area of fire grate in sqr. feet.	Surface in water space above grate bars in sqr. feet.	Super-heating surface in steam space.	Actual H. P. to be worked on the brake.	Indicated H. P. at actual speed.	Ratio of brake-power to indicated power at same speed.	Coal burnt per square foot of grate per hour.	Cold water evaporated per lb. of coal.	Cold water evaporated per indicated H. P. per hour in lbs.	Cold water in cubic feet evaporated per hour.	Square feet of heating surface per indicated H.P. of engine.	Cold water evaporated in cubic feet per hour from and at 212°.	Estimated am't which would have been evaporated with an economy of 8 lbs. of water.	Pounds of water evaporated from and at 212° per lbs. of coal.	Square feet of heating surface required to evaporate a cubic foot of water from and at 212°, estimated at an economy of 8 lbs. of water.
1	6·5	204·4	0	30	39	·86	19·3	7·62	24·5	15·3	5·2	16·5	17·0	8·22	12 AVE'G.
2	4·33	106	0	18	24	·88	21·5	7·46	29·0	11·1	4·4	11·9	11·9	8·00	8·9
3	4·33	106	0	15	21·9	·85	19·1	7·76	29·2	10·2	4·8	11·4	12·35	8·67	8 58 9·94
4	3·9	145 3	0	16	21·7	·83	23·3	7·36	30·8	10·7	6·7	11·7	11·9	8·04	12·
5	4·23	154·2	0	20	26·5	·85	31·7	7·28	37·0	15·7	5·8	18·2	19·2	8 44	8 03
6	6·0	184	92·	30	35·8	·87	28·5	5·48	32·7	18.7	5·1	22·5	18·56	6·6	9.9
7	5·25	80·5	46·	24	30·8	·83	23·8	6·72	27·4	13·5	2·6	16·1	16·1	8·0	5 5·35
8	5·41	85·5	35·2	24	30·7	·76	27·0	5·95	28·3	14·0	2·8	16·8	15·0	7.14	5.7

The last column gives the heating surface required as near as can be estimated from the report of the Society.

These engines use a forced draught, and burn a large quantity of coal per square foot of grate. The heating surface is the total amount, without any deductions.

Marine Boilers.

We extract from Isherwood's Engineering Precedents as follows:

"*Experiments on eight different Marine Boilers to determine the evaporative efficiency.*"

Name of Steamer.	Description of Boiler.	Total heat. surface of boiler.	Heat'g surface requi-red pr H.P.	Water evapor'd pr. lb. of combus.	Combustib'l burnt pr sq. ft. of grate.
Jacob Bell,	Hor. Tubes & Flues,	1484	19	12	11
Mount Vernon,	Hor. Tubes,	2374	19	10·5	10 5
Valley City,	Hor. Tubes,	953	16	11·2	9·16
Crusader,	Hor. Tubes,	1056	16·8	11 8	9·3
Wyandotte,	Martin Vert. W. Tubes,	1993	20	12 4	10·
Underwriter,	Hor. Flue, 12″ & 20″,	1817	15·6	11·2	9·9
Young America,	Hor. 6″ Tubes,	981	15	10 4	9·3
Boiler of N. Y. Navy Yard,	Hor. Tubes,	1143	18	11·1	11·5
			139·4	90·6	80.6
Average,			17·4	11·3	10·0

In these trials the boilers were not pushed to the full capacity on an evaporation of nine lbs. of water, or we should find that less heating surface would have been required.

From the same source we also extract as follows:

Experiments with vertical water tube boiler and natural draft.

Name of Steamer.	Total Heating surface of boiler.	Heating surface required per H. P.	Water evaporated pr. lb. of combustible.	Comb. burnt per sqr. foot of grate.
San Jacinto,	3295	18 ft.	12·6	9·9
The same with forced draft.				
"	3295	10 ft.	8·67	19·8

Horizontal fire tube boiler, natural draft.

Name of Steamer.	Total Heating surface of boiler.	Heating surface required per H. P.	Water evaporated pr. lb. of combustible	Comb. burnt per sqr. foot of grate.
San Jacinto,	2663	16 ft.	10·8	10.7
The same with forced draft.				
"	2663	10 ft.	8.	20·

From the above it appears that the heating surface required to evaporate one cubic foot of water from and at 212° (economy 9 lbs. of

water) ranges between 12 and 14 feet, calculating all the H S. as effective.

The present practice of the U. S. Navy is to allow 8 lbs. of anthracite coal per hour to evaporate one cubic foot of water at 100° into dry steam, under a pressure of 30 lbs. above the atmosphere, which requires $\frac{3}{4}$ square foot of grate, $16\frac{2}{3}$ square feet of heating surface, and one-twelfth square foot calormeter.

Sectional and other Boilers tested at the Fair of the American Institute, New York, 1871.

The report of this trial having appeared in full in a previous number of the Journal, we shall only extract the most important portion.

The boilers tested were as follows:

The Root.—This boiler consists essentially of 80 wrought-iron tubes 4 inches diameter and 9 feet long. These tubes are set in brick work at an angle of about 30° from the horizontal.

The tubes are connected together at the ends by a system of triangular plates and crowfeet. The boiler has a steam drum 18 inches by $6\frac{1}{4}$ feet long. The superheating is effected in the upper portion of the boiler.

In calculating the heating surface of these boilers, the total area exposed to contact with combustion is taken as heating surface.

The Allen Boiler.—In this boiler the roof of the fire chamber is made of nine cast-iron cylinders, each 7 inches internal diameter and 11 feet long; and into each of these cylinders 18 wrought-iron tubes, $3\frac{1}{2}$ inches in diameter, are screwed, the lower ends being closed by plugs. These tubes hang down from the roof into the fire chamber, and are set at an angle of about 20° from the vertical; the lower end being furthest from the fire door. The tubes over the fire are 3 feet two inches long, the rear ones are 4 feet 5 inches long. Steam drums are arranged over the boiler.

The Phleger Boiler.—This consists of a number of wrought-iron tubes, nearly horizontal, connected to wrought iron tube plates and set in brick-work. There are 17 bent tubes, 2 inches in diameter and 15 feet long, so arranged as to form the furnace and water grate, being secured at the ends to wrought iron tube sheets. There are also 68 straight tubes of the same dimensions, secured at the ends to wrought tube sheets. These tubes are all connected with each other and the steam drum, which is $2\frac{1}{2}$ feet diameter and 12 feet long, and which contains shelves or the prevention of foaming.

The Lowe Boiler.—This is a horizontal tubular boiler, with the fire under one end. The products of combustion pass within the boiler to a combustion chamber, then through the tubes and around the under side of the shell of the boiler. In the trial, two boilers placed side by side were tested. The larger boiler was 4 feet diameter, 15 feet 4 inches long, and contained 45 tubes 3 inches in diameter and 12 feet long.

The other boiler was of the same length as the first, but only $3\frac{1}{2}$ feet in diameter, and contained 36 tubes 3 inches in diameter.

The Blanchard Boiler.—This boiler has a fire-box similar to a locomotive, and the fire-tubes, instead of being horizontal, are vertical, and at the rear end of the fire-box. These tubes are 94 in number, and $4\frac{1}{2}$ feet long by 2 inches in diameter. A superheater is above these tubes, but it was not used in the trial.

In the test of these boilers we have the first attempt to estimate the true evaporation. This was done by condensing all the steam made by passing it into a tank in which was a condensing pipe having 1100 square feet of surface. The temperature of the water of condensation, as also that of the condensing water, being constantly noted as it escaped, the amount of water evaporated into steam could be calculated therefrom. There are other less expensive methods than the above described, by which the true amount of water evaporated may be arrived at sufficiently near for practical purposes.

The table which follows shows the result of the trial.

The trial above recorded shows what amount of water can be evaporated per pound of combustible, rather than the heating surface required in the usual conditions of use. We cannot, from the figures here given, even approximate to the heating surface required at an evaporation of 9 pounds of water. Estimating the power of a boiler by the heating surface, as is common with boiler makers, we conclude that the Allen boiler shows the greatest economy, having evaporated 10·60 pounds of water per pound of combustible, with 17·41 feet of heating surface, the other boilers requiring 22 feet and over. It is evident that considerably less than 17 feet will answer per horse power on this boiler, when new, but how much less the experiment does not show.

To make a trial like this thoroughly practical in its utility, we should have the tests made at two or three different rates of evaporation within the limits at which the boiler is likely to work. The pur-

Results of the competitive trial of Steam Boilers at the Fair of the American Institute, November, 1871.

NAME.	Square Feet. Grate surface.	Square Feet. Heating surface.	Ratio of heating surface to the grate surface.	Total Weights. Coal.	Total Weights. Combustible.	Total Weights. Feed.	Total Weights. Steam.	Total Weights. Primed water.	Ratio of water primed to water evaporated.	Mean Temperatures. Injection.	Mean Temperatures. Feed.	Mean Temperatures. Water of condensation.	Mean Temperatures. Discharge.	Mean Temperatures. Steam.	Mean Temperatures. Super heat.	Mean Temperatures. Flues.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.
Root	27	876½	32·5	3800	3180·5	27896	27896	0.	0.	45°·94	45°·94	86°·31	145°·1	334°·6	16°·06	416°·6
Allen	33¼	920	28·5	5375	4627	39670	39870	0.	0.	45°·5	45°·5	63°·48	154°·76	330°·63	13°·23	345°·87
Phleger	25	600	20·1	2800	2274	20428	19782·91	645·09	3·26	45°·65	45°·65	54°·38	120°·83	321°·06	0°.	369°·6
Lowe	37¾	913	24·2	4400	3705	34600	31663·35	2336·65	6·9	45°·0	45°·0	64°·8	131°·5	319°·48	0°.	221°·97
Blanchard	8½	440	51·8	1232	1047·5	10152·5	9853·6	298·9	3	44°·4	44°·4	49°·49	106°·14	325°·75	0°.	

Results, etc.—Continued.

NAME.	Total British thermal units.	Total units per pound of combustible.	Apparent Evaporation. Per pound of coal.	Apparent Evaporation. Per pound of combustible.	Apparent Evaporation. Per square foot of grate surface per hour.	Apparent Evaporation. Per square foot of heating surface per hour.	Actual Evaporation. Per pound of coal.	Actual Evaporation. Per pound of combustible.	Equivalent evaporation of water at 212° Fahr. and atmospheric pressure.	Square feet of heating surface required to evaporate one cubic foot of water per hour.	Coal, lbs. per square foot, grate surface per hour.	Efficiency: actual evaporation of fuel divided by theoretical.
	Q.	R.	S.	T.	U.	V.	W.	X.	Y.	Z.	Z. 1	R. 2
Root	32,751,834·34	10,291·53	7·34	8·76	86·70	2·65	7·34	8·76	10·64	23·59	11·73	0·709
Allen	46,387,827·1	10,246·92	7·38	8·76	102·51	3·59	7·38	8·76	10·60	17·41	13·38	0·707
Phleger	23,066,685·39	10,143·66	7·26	8·95	73·70	2·83	7·27	8·70	10·49	22·74	10·13	0·699
Lowe	37,228,739·072	10,048·24	7·66	9·12	75·06	3·10	7·29	8·55	10·40	21·63	9·71	0·693
Blanchard	11,485,777·35	10,364·94	8·24	9·69	99·83	1·92	8·00	9·41	11·54	33·46	12·10	0·756

chaser could then choose the boiler, and the amount of heating surface corresponding to the economy desired.

It is very important that all trials, to be of practical use, should be made as near as possible under the same conditions at which the boiler is intended to work in actual commercial use.

Multitubular Boiler.

We have received from Mr. H. S. Robinson, Engineer at the Pacific Mills, Lawrence, Mass., the results of a careful trial of a steam-boiler at those works, the trial ending July 19, 1871.

The boiler is cylindrical and horizontal, 21 feet long and 5 feet diameter, having 58 tubes, 3¼″ diameter 20 feet long, set square, 1 inch apart and 3 inches from the shell. Smoke-box, 12 inches, projecting into the fire-room. The boiler is fired externally, the gas passing under the bottom and back through the tubes. The trial lasted 49 hours; average pressure of steam, 49 lbs.; steam apparently dry.

There is no superheating. Grates, 5′ 2″ long.

Heating Surface of Boiler.			Grate Surface.	Temperature of Flue.	Pounds of water evaporated per hour from and at 212°.	Pounds of Combustible burnt per sq. ft. of grate.	Pounds of Water evaporated per pound of Combustible.	Pounds of Water evaporated per square foot of Heating Surface per hour.	Square feet of Heating Surface required to evaporate 1 cubic foot of Water per hour.
Shell exposed to Heat.	Total Surface of Tubes.	Total.							
			First Trial with Anthracite Coal.						
140	1063	1203	25. 8	332°	2883	9·5	11·7	2·396	25
			With Hampshire & Baltimore Co.'s Soft Coal.						
140	1063	1203	25·8		3090	9·5	12·63	2·568	23

In examining this report, we note the low temperature of the escaping gases, the small quantity of coal burnt per sq. foot of grate, the great economy in the water evaporated, and the large heating surface required.

The bituminous coal evaporated the most water.

The rate of economy is so much above the average, that we could not even approximate from this trial what heating surface would be required at an economy of 9 lbs. of water.

Mr. Robinson has also furnished us with a trial of a Harrison cast-iron boiler, made at about the same time and with the same coal.

This boiler was in the same shed as the multitubular boiler, and was set according to the usual plan of the maker. The boiler itself is too well known by the public to need any particular description. This one consisted of 8 slabs, the superficies of which is estimated at 90 feet each, making a total of 720 sq. feet of heating surface.

Total Heating Surface of Boiler.	Grate Surface.	Pounds of Combustible burnt per sq. ft. of Grate.	Temperature of Flue.	Pounds of Water evaporated per hour from and at 212°.	Pounds of Water evaporated per pound of combustible.	Pounds of Water evaporated per sq. foot of Heating Surface per hour.	Square feet of Heating Surface required to evaporate 1 cubic foot of Water per hour, from and at 212°.
First Trial with Anthracite Coal, lasting 48 hours, ending 6½ A.M., July 1st.							
720	24·37	9·7		2251	9.48	3·126	19·04
First Trial with Bitumin				ous Coal, ending June 29, 1871.			
720	24·37	8·7		2065	9·74	2·868	20·74
Second Trial with Anthracite Coal, ending 6½ A.M., July 22, 1871.							
720	24·37	4·6	427	1227	10·84	1·704	34·9
Second Trial with Bituminous Coal.							
720	24·37	5·4	391	1385	10·42	1·923	30 9

It will be observed that in this trial, as also in the previous one of the multitubular boiler, and the sectional boilers in New York, that the evaporative economy is much above 9 lbs. of water per lb. of coal, requiring a larger amount of heating surface than would usually be given per horse-power by the maker.

Recapitulation.

With the limited number of accurate experiments available upon which to base the heating surface required on various boilers to evaporate a cubic foot of water per hour from and at 212°, and recognizing fully the various causes modifying the heating surface required, as given in the preliminary report, your Committee can only give an approximate estimate, based upon the preceding tables of trials, and under the conditions therein stated.

From the Report of R. B. Longridge.

	Feet.
Plain Cylinder Boiler with Flues, reckoning surface exposed above heat only, or against which the current strikes, economy 9 lbs.,	8·8
Galloway and Galloway Multitubular,	8·5
Multitubular, Figure 14,	5·8
" " calculating the total surface of the tubes,	11·2

The following are calculated at the total heating surface:

From Isherwood's Engineering Precedents.

Marine Boiler, horizontal tubes,	14·

From Report of Messrs. Eastons & Anderson.

Double-Flue Cornish Multitubular, nearly similar to Figure 14,	11·7

From Report of the Royal Agriculture Society, England.

Portable Engines, forced draft, economy 8 lbs. of water.

Locomotive Boiler,	10·
Howard's Section Water Tubular,	10·
Pot Boiler,	5·35

In estimating the heating surface required to evaporate a cubic foot of water in similar boilers, a small addition must be made to the above figures, depending upon the temperature of the feed entering the boiler, and pressure of steam.

In conclusion, your Committee return thanks to those Engineers who have favored them with their opinions, or assisted in furnishing materials for this report.

EDWARD BROWN,
JOHN H. COOPER,
W. BARNET LE VAN,
WILLIAM H. WAHL.

Hall of the Institute, June 18, 1872.

After the reading of the paper it was, upon motion, resolved that the thanks of the Institute be presented to the Committee for the labor and time bestowed in preparing their valuable report, and that the October meeting of the Institute be fixed as the time appointed for discussing the report.

THEORY AND CONSTRUCTION OF THE SELF-ACTING SLIDE LATHE.

A Paper read before the American Railway Master Mechanics' Association, at the Meeting of the Association, held in Boston, Mass., June, 1872.

By COLEMAN SELLERS, *Associate Member.*

[Revised for publication in the Journal of the Franklin Institute.]

In compliance with the request to furnish a paper to be read before the American Railway Master Mechanic's Association, at their meeting in Boston, it has occurred to me to present a few thoughts on the theory and construction of that important machine—the self-acting slide lathe.

Prominent in the list of tools for the equipment of the workshop stands the lathe. It was th efirst machine tool; it is the most important. Upon it has been expended much thought, and about it much has been written. My excuse for treating of it is that, during the past few years, the lathe has been much improved; its functions have been carefully studied, and its form changed to agree with the now better known theory of its operation. Traditional shapes and devices have been discarded, and new ones are becoming familiar to the men who work at it.

It must be conceded that the requirements of a good turning lathe are that it must turn a true circle, it must turn a true cylinder, and it must, when facing off, produce a true plane surface. The screw cutting lathe must, in addition to these requirements, produce a sufficiently perfect thread. It is not only necessary that the lathe should fulfil these requirements when new, but it should continue to fulfil them year after year, with the least possible need of adjustment and repair. It has been said that good workmen can do good work with poor tools. Skill and ingenuity may indeed accomplish great results; but the problem of the day is not only how to secure more good workmen, but how to enable such workmen as are at our command to do good work, and how to enable the many really skillful mechanics to accomplish more and better work than heretofore; in other words, the attention of engineers is constantly directed to so perfect machine tools as to utilize unskilled labor.

The turning lathe, being the oldest of all machine tools, has been more hampered by traditional devices and shapes than more recently contrived machines. Changes for the better have to be made, often in opposition to prejudices of the workingmen. This opposition has not, however, deterred engineers from steadily improving the machin-

ery they design, as new uses and new requirements seem to demand a change. Much more is required of the turning lathe now than was thought of but a few years ago; more and better work must be done by it with less skilful workmen, and it must be adapted to the various kinds of work required of it in particular kinds of manufactures. Thus many lathes, adapted to special purposes, have been designed and designated by the names of the classes of work they are intended to accomplish. Through all the various forms of lathes there are certain parts and principles in common, and these parts or principles may be considered without treating of special or unusual forms. Certain general types of the parts of lathes have become as well known by name as any other familiar objects, and mechanics can readily understand the characteristics of these peculiarities when brought to their notice by name only.

Thus, to speak of a lathe shear as a V shear or flat top shear, conveys to those for whom the remarks are intended, a sufficiently clear idea of the two principal forms of the lathe bed or shear now in use. The V shear has been the favorite in this country for many years; the flat top shear is the rule, not the exception, in England. In view of the well-known fact that durability of machinery is largely dependent upon extended surface, where surfaces move or slide one on another, it is rather surprising that the flat top shear should have met with so little favor in this country up to quite a recent period. Theoretically, it presents the largest wearing surface, and is the most easily made. The saddle of the slide rest, bearing over its whole under surface, may find a support up to the edges of the centre opening of the shear. Having less distance to span unsupported than on the V shear, the saddle can be made thinner and yet strong enough, thus increasing the capacity of the lathe swing over the slide rest. On lathes with V guides there are usually four of these guides, the two outer ones serving as guides for the saddle, and the saddle must, of necessity, span the entire space unsupported from one V to the other; hence it must be thicker and heavier than if resting on a plane surface. The nominal capacity of any lathe is what it will swing over the shear. The actual capacity in relation to cylindrical work is what it will swing over the slide rest; hence the advantage of less thickness in the saddle, if of sufficient strength.

Those workmen who have not used lathes with flat top shears are apt to think that the extended surface in contact with the shear may make it hard to move. If it be allowed to stick fast with gummy oil

this may be so, but with such care as any machine tool should receive at the hand of the workmen, it is really easier to move. Friction being dependent upon weight not surface, the flat top shear, owing to the extended bearing surface, will permit the use of much lighter saddle, and the dust and dirt is no more apt to catch upon the flat shear surface than on the V shear, and is as effectually pushed off by the saddle. Lightness in the slide rest becomes of great moment on lathes of large capacity, and is worth considering in all lathes.

The flat top shear can be readily planed true on its upper face, on its outer edges and on its inner edges. The outer edges guide the saddle, lost motions being taken up by shoes or gibs. The lathe heads are guided by the inner edges. The parallelism of all these edges can be readily insured. Convenience in moving requires that the poppet or back head, which (with the flat top shear) is guided by the inner edges of the shear top, should slide easily, and hence should fit loosely. It is of the utmost importance that it shall always hold the same position as to line with the other parts of the lathe when clamped. This suggests the placing of a V on the under side of one of the inner edges, and thus, by means of the clamping shoe, draw the head always up to the same straight-edge. I consider this combination of a clamping V on the under side of the shear top with the flat surface above it as one of the most important modern improvements on the lathe. The idea originated with Mr. William Sellers, of Philadelphia. It is one of many very advantageous changes made by him, and is the result of many years' study of this important tool.

The function to be performed by the lathe shears or bed is to maintain the driving head or live head spindle in line with the poppet head spindle, and to carry the cutting tool parallel with this centre line. It must do this under various conditions of strain. Screwing up the centre to hold the work, tends to bend the shear in one direction. The strain of the cut tends to bend it in another, in fact, in several directions.

It must be borne in mind that the lathe centres, being above the shear, and dependent entirely on the stiffness of the shear for their rigidity, are placed at some disadvantage in regard to leverage. A clear idea can be obtained of resultant strains if thought be directed to a lathe with a rigidly fixed live head and a very flexible shear. The work, being also rigid, will be driven around its axis by the rotation of the live head spindle, and will therefore tend to turn the

slide rest, the shear and the poppet head around the axis of rotation, thus producing a severe torsional strain on the bed. Hence the bed must resist strain in all directions; the longer the bed the more elastic it would be in regard to torsion, if it were not for the system of cross-girts introduced in all first-class lathe beds. These cross-girts should extend up as far as possible, and form inflexible ties between the two I beams, which represent the sides of the shear. The lead screw in screw-cutting lathes should be placed within the bed, and when supported over its entire length by resting on a trough planed out to receive it, is not subject to deflection, maintaining its right line will produce a truer thread, than if unsupported, except by the nut and end-bearings. By being placed under the shear top, it is entirely protected from falling chips and dirt.

Upon the perfection of workmanship on the spindle of the live head depends the possibility of turning a true circle; upon its freedom from end motions and the exact placement at right angles to it of the line of cross slide of the slide rest, depends the possibility of producing a true plane in facing.

The spindle must be round—truly round—as it will reproduce its own shape in the work being turned. Theoretically, a hardened steel spindle, running in hardened steel bearings, the spindle and bearings being made true after having been hardened, presents the most reliable conditions of correctness and durability. Fortunately, the modern improvements in methods of working hardened steel, furnish means of perfecting this important part of the turning lathe; but to adapt it to the possibility of economical construction, more important changes must be made in form. The customary collars at each end of the journal must be dispensed with, and the front journal of the spindle made truly cylindrical and supported over its entire length by a truly cylindrical bearing. The back bearing may be conical, and one stationary ring or collar of hardened steel secured to the spindle back of the back bearing, may be ground true and be made to run between hardened steel plates without any lost motion whatever, and no liability to stick or jam. This form of back thrust does away entirely with the tail screw, presents a more extended and durable wearing surface, and permits the spindle to be extended through the back support, and thus receive change wheels of any size for screw cutting or feed. The form of the live head-stock should be such as to hold the front bearing in a rigid manner against lateral strains, and the back bearing against a strain of the spindle pressed endways.

The cone speeds should be so proportioned to the gearing on back-geard and tripple-geared lathes as to insure an exact ratio of change from the fastest to the slowest speed in each and every change,—that is, with five lifts to the cone in a tripple-geared lathe, 15 speeds should be possible, each proportionately slower than the one next to it. The cone pulley or spindle should be of iron turned inside and out so as to be perfectly balanced, and should, in its inner sleeve, present an extended bearing upon the spindle capable of proper lubrication. The spindle should be of the best cast-steel, and being first roughed out, should be hardened and then reduced to proper shape and size by suitable machinery. The taper hole for the live centre should be finished true after the spindle is made true on the outside. The truth of this hole is just as important as the accuracy of the outside of the spindle. Upon its absolute concentricity with the outside of spindle depends the possibility of the centre point running true, no matter how replaced after it has been taken out.

Too much care cannot be taken with the manufacture of this important part of the machine. Hardened steel spindles have been made in this manner for lathes as large as 48″ swing, the front journal of such a lathe being 5 inches in diameter; but the practical difficulties in the way of working with safety such large masses of hardened steel, prevents its adoption for spindles over about three inches in diameter.

On all double-geared lathes the face plates should be made to unscrew for convenience of changing to various sizes and the ready application of chucking devices. The overhanging end of the lathe spindle to receive the face plate should always have a portion of its length next to the shoulder, cylindrical without any screw thread. The screw on the end may be short and should fit loosely in the face plate; but a careful fit should be made in the face plate of the part carried by the plane part of the spindle, and the shoulder against which the nut of the face plate abuts should be made very true. This arrangement insures the face plates always running true, no matter how frequently they are changed, nor how loosely the screw may fit, provided they are not bruised or injured in the fitting parts.

I would here remark that spindles made as described have been tested during many years' constant hard usage, and have been found to show no appreciable wear. Possible abjustment of all wearing parts should be provided, but such adjustment should not be at the convenience or whim of the workman using the machine, as is the

case with the spindle collared at its journals and provided with a tail screw for the back thrust. I have already mentioned the method of holding the poppet head so as to insure its alignment by means of the V on the under side of the flat top shear. Its spindle should be carefully fitted, and a device recently patented by Mr. Faught, with A. Whitney & Son, Philada., is of great use in insuring stability. He clamps the spindle at the extreme end of the bearing by means of a split conical sleeve forced in by a screw, which takes up all lost motions or play and insures its central position. If lathes were not required to turn tapers as well as cylinders, there can be no doubt that the poppet head, made in one piece, resting on the shears over a sufficiently broad surface and capable of adjustment sideways only to the extent of practical alignment, would be the simplest and the best. In our own practice we prefer this system, and adapt to lathes requiring it a device which enables the turning tool to be guided by former bars, and thus to produce tapers or irregular shapes, such as the curves of handles, &c. This device, called technically "a former attachment," does much better conical or tapered work than with the centre set over out of line for reasons too obvious to all mechanics familiar with the use of the machine, and gives a greater range to its capacity. I may be pardoned for mentioning in this relation what we consider the readiest method of bringing the centre in line after the head has been set over, in adjusting the centres in the first place, or in testing the correctness of a new lathe. A bar of round iron carefully centered, is turned up a short distance on one end. This turned end being placed next to the live head centre, a turning tool clamped in the slide rest is made to just touch the turned part. Taking out the bar, the tool is then moved over to the poppet head spindle, and the bar reversed with its turned end next to poppet head centre, when, if the tool just touches the turned part as before, the lathe may be considered in adjustment.

A vertical adjustment to the point of the turning tool is of the utmost importance in lathes and for turning work of small diameter. The larger the diameter of the work to be turned, the less need of such adjustment; in other words, the more latitude there may be in the position of the tool point. Lathes of 16″ swing and under should be provided with some means of raising or depressing the point of the tool. Large lathes, where the rests are compounded, may dispense with this. The feed for turning should be independent of the feed for screw cutting. The changes of speed to the feed for turning

should be capable of gradation to suit the nature of the work between the extremes of speed. When (as is the case in large lathes,) there is an automatic cross feed provided, the various feeds should be so arranged as to be readily changed from one to the other. Having set in gear any one of the feeds, it should be stopped and started by one and the same motion for all the feeds. Such motions as screwing up the spindle of the poppet head, stopping and starting feeds, setting up the slide rests, &c., are motions of habit, and should, if possible, be uniform on all lathes. This is especially the case where two kinds of feed are operated by the same starting gear. No complication of motions should embarrass the workman. There should be no hesitation on the part of the workman as to which way he should move the starting gear in any case. The cross slide of the slide-rest, in fact, all the slides of the rest, should be so made as to entirely cover their sliding surface, and thus exclude all dirt. This is of the utmost importance, and too often neglected by makers of otherwise very good lathes.

For lathes up to 36″ swing the very convenient single screw tool post can be used to advantage; but for larger lathes it is not possible to hold the tool in this manner alone, if the lathe is proportionally powerful. Four screws or standing belts with clamp plates serve a better purpose and admit of a greater range of tool positions.

What I have thus presented in relation to the prominent features of the self-acting slide lathe is, in reality, the result of many years' observation and study of this important tool by some of the best engineers and noted by me during a somewhat extended familiarity with the tool as a workman and designer of tools. A turning lathe, as of all other machines, should not be made up of a collection of conventional forms and devices without any good argument to recommend their use. It should be capable of analysis, and each and every part should be constructed with a view to the end to be obtained. Workmen, when testing tools so constructed, are soon convinced of the advantage. Railway master mechanics have better opportunities of examining into the merits of machine tools than many others, and are ever the readiest to appreciate improvements It is with great pleasure, therefore, I present these observations to them and hope they may at least suggest thought, and aid them to inquiry into the merits of the tool so constructed.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 28.)

In the last article on wood-cutting machines, we alluded to rotary mortising machines as superseding those with reciprocating motion. We present in this number a true elevation of a machine of this kind, adapted to railway carriage and other framing requiring rectangular mortises (shown at fig. 1 on the plate). The elements of the machine may be said to consist in a rotary cutter spindle, that has a lateral adjustment up and down on the main column, to determine the width of the mortise and its position across the piece; a long traversing carriage, on rollers, that is moved either by power or by hand, as the nature of the work may require; and the shafting seen on the left of the side view.

The vertical movement of the spindle is regulated by a system of adjustable stops, four in number, that gauge the position of the cutting tools to four points, and when set for any special piece any number of duplicates can be mortised without "laying out," and without possibility of mistake.

The same system of stops is used to regulate the longitudinal movement of the table or carriage, so that the length of the mortises and the distance between them is determined by the stops without laying out, as in the other case.

The tables of these machines are made from twenty to forty feet long, of heavy timber, bolted together, and although quite heavy, to prevent being sprung by crooked timber, is moved upon the roller rests with but little power. The belt connection is arranged to traverse the carriage at a speed of 100 feet per minute, and is mainly used in "running off" and loading the timber. The cutter spindle has a lineal adjustment of about six inches, and runs at a speed of 5500 revolutions per minute.

The machine is adapted not only to cutting mortises, but can be used for facing, or what is technically termed "boxing," meaning a flat space on the timber to receive the shoulders of the tenoned piece. This is done by traversing the spindle up and down across the face, and at the same time moving the timber longitudinally. When the boxing is done the mortise can be made with the same stool, and

without other change than to swing the top stops (seen on front view) into place.

Fig. 2 on the plate is a true elevation of a "cross-graining and notching machine," for work of the same class. Car timber, bridge timber, or other framing of a similar character, can be rapidly cross-grained, as in the case of mortising without "laying out."

The action of the machine, so far as the movements are concerned, is analagous to a metal-shaping machine. The spindle is carried on the front of a strong reciprocating bar, that has a stroke of twenty inches, arranged with a quick return motion, similar to that invented by Sir Joseph Whitworth, and applied in his metal-shaping machines. The mechanism is, however, quite different, being merely a slotted sink, operated by the gearing seen on the side view.

The spindle has a vertical adjustment on the front of the cutter-bar, regulated by adjustable stops that gauge the depth of the cut at each stroke. The timber is clamped on a strong traversing frame of iron, that is provided with a system of stops to regulate the width of the gains or notches, which can be made at one or more strokes of the cutter-bar, as their width or depth may require.

These machines are manufactured by Richards, London & Kelly, at the Atlantic Works, in this city, and have been arranged to meet the demands of the enormous car-building interest developed in this country. The machine for cross-graining was prepared at the suggestion of Mr. I. Dripps, late Superintendent of motive power of the Pennsylvania Railroad Company, to meet the demands of the vast business done at their works, at Altoona, Pennsylvania, where some three thousand men are employed in the car department alone. The writer, when at Crewe, England, some five months since, visited the works of the London and Northwestern Railway Company, at that place, and after being astonished at the vast and perfect appliances for metal working, was disappointed at finding the "wood department" but a small place; the machinery was good, but not enough of it in all to perform a single function in the works at Altoona. The company, however, have other, and larger shops at Woolverhampton, near London, where the wooden interiors for passenger coach wheels are made. The special machines for this purpose were made by Greenwood & Batley, of Leeds, and for a wonder was regarded as of sufficient interest to be inserted by Mr. Rankine in his late work on machine tools.

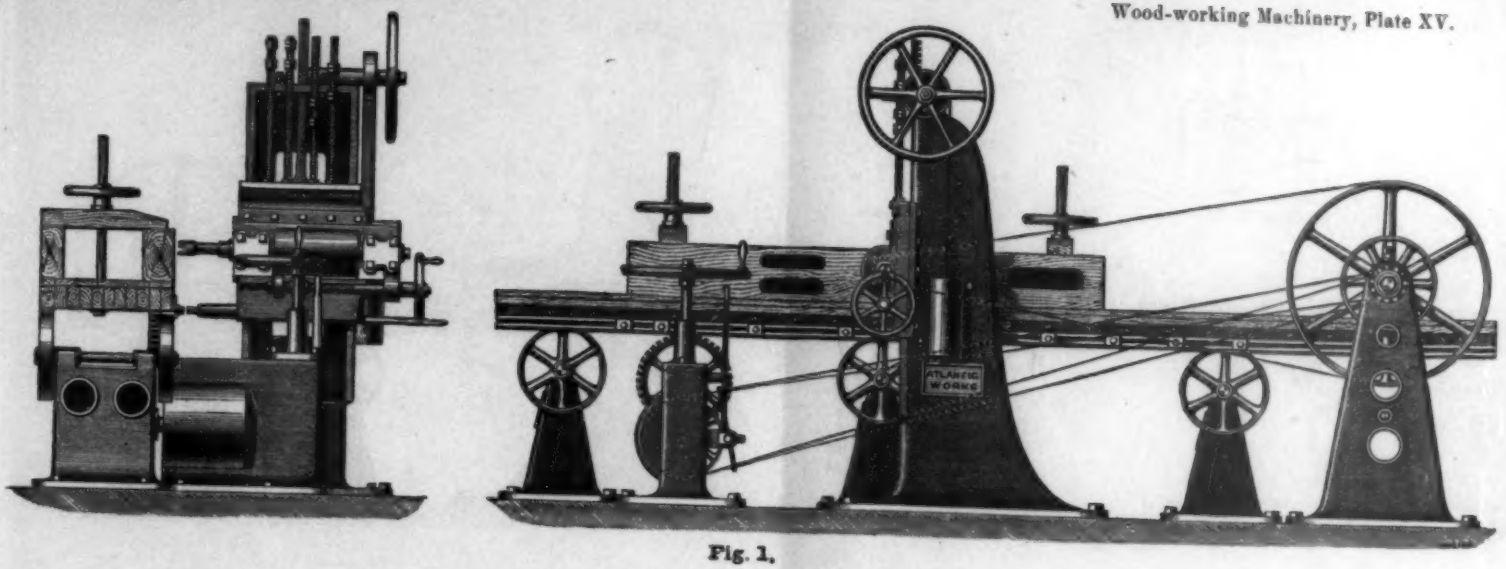


Fig. 1.

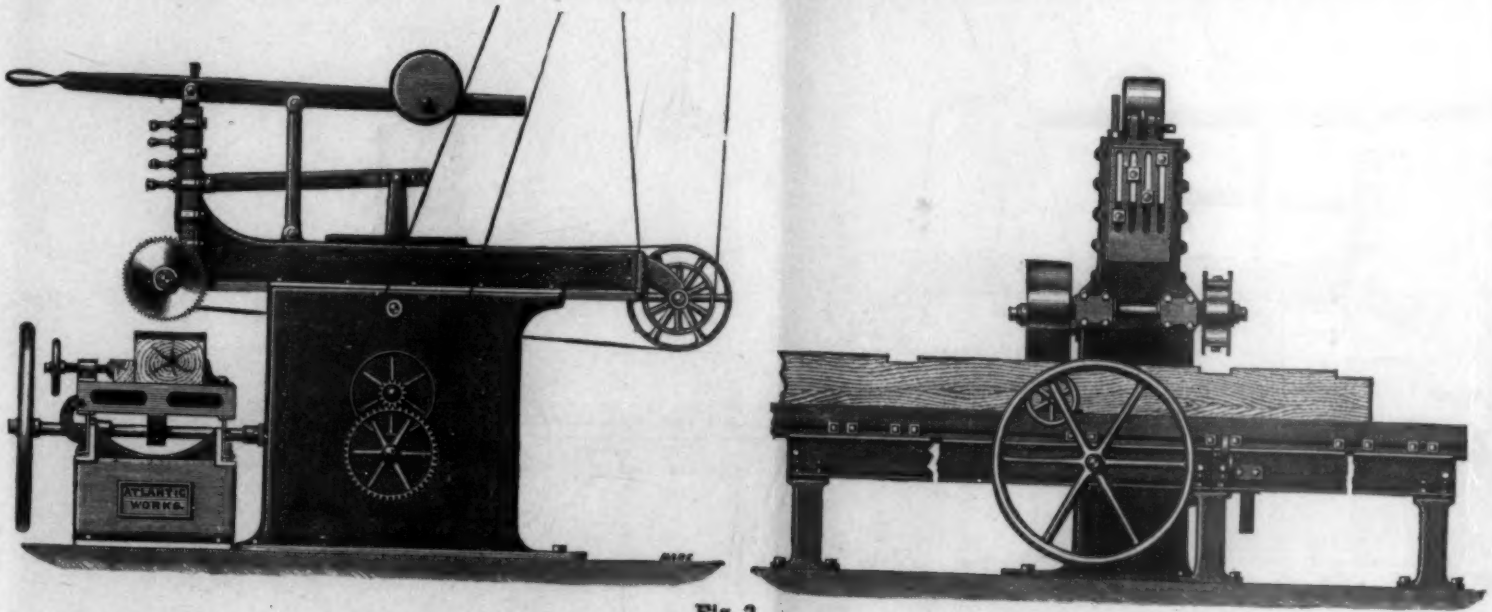


Fig. 2.

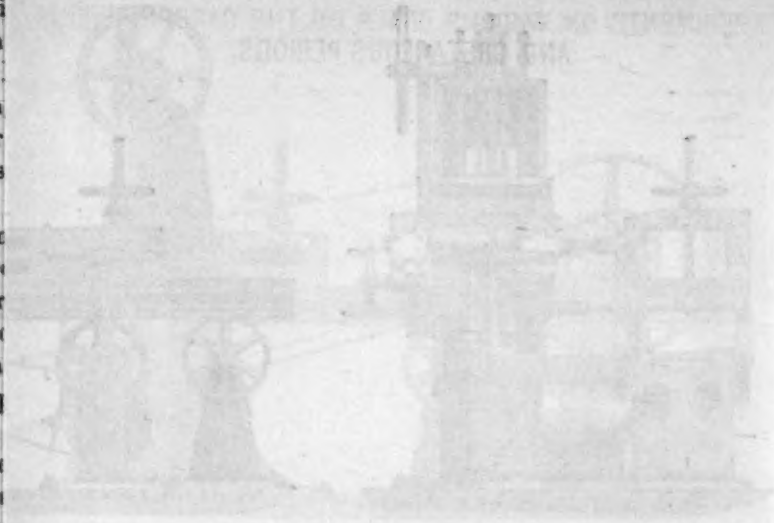


TABLE No 1.—*Containing the data and results of the experiments made in* 1871, *with the machine-shop boiler of the United States Navy Y*
of Pennsylvania anthracite, Welsh anthracitic, and Maryland semi-bituminous coal, of the carboniferous period; also, of Queen Charlotte

Number of line.		ANTHRACITE. From the Scranton mines of Pennsylvania.			ANTHRACITE. From Queen Charlotte Island.	WELSH ANTHRACITE. From Western Wales.		
		Maxim'm combustion.	Medium combustion.	Slow combustion.		Maxim'm combustion.	Medium combustion.	Slow combustion.
1	Date of commencing the experiment,...	*March* 8, 9 *a. m.*	*Jan.* 18, 10.30 *a. m.*	*Feb.* 20, 8.30 *a. m.*	*Jan.* 19, 3 *p. m.*	*Sept.* 11, 9 *a. m.*	*Sept.* 8, noon.	*Sept.* 12, 2 *p. m.*
	TOTAL QUANTITIES.							
2	Duration of the experiment, in hours,...	24	24	24	22	24	24	24
3	Cubic feet of water vaporized from the temperature of the feed-water,...	755.550	644.000	408.110	400.000	829.048	685.622	531.635
4	Pounds of water vaporized from the temperature of the feed-water,...	47,080.116	40,065.164	25,423.968	24,885.195	51,432.970	42,543.018	31,006.141
5	Pounds of coal consumed,...	6,679	5,636.	3,725	4,976	6,354	5,330	3,737
6	Pounds of ash from the coal,...	679	514	479	1,229	423	349	115
7	Pounds of clinker from the coal,...	279	295	134	749	67	50	36
8	Pounds of ash and clinker from the coal,...	958	809	613	1 978	490	390	151
9	Pounds of combustible consumed,...	5,721	4,827	3,112	2,998	5,864	4,940	3,484
10	Per centum of the coal in ash,...	10. 17	9. 12	12. 86	24. 70	6. 66	6. 38	3. 16
11	Per centum of the coal in clinker,...	4. 17	5 .23	3. 60	15 05	1. 05	0. 96	0. 99
12	Per centum of the coal in ash and clinker,...	14. 34	14. 35	16. 46	39. 75	7. 71	7. 34	4. 15
	PRESSURES AND TEMPERATURES.							
13	Temperature, in degrees Fahrenheit, of the external atmosphere,...	54. 1	47. 0	45. 6	42. 6	62. 9	63. 4	68. 2
14	Temperature, in degrees Fahrenheit, of the boiler-room,...	67. 8	67 6	66. 5	64. 1	75. 3	74. 5	80. 8
15	Temperature, in degrees Fahrenheit, of the feed-water,...	63. 5	77. 0	66. 0	77. 0	94. 0	93. 0	90. 0
16	Height of the barometer, in inches of mercury,...	30. 04	30. 14	29. 95	30. 35	29. 96	29. 90	29. 91
17	Steam-pressure in the boiler, in fraction of a pound per square inch above the atmosphere,...	0. 110	0. 101	0. 050	0. 050	0. 090	0. 025	0. 015
18	Steam-pressure in the boiler, in pounds per square inch above zero,...	14. 85	14. 90	14. 75	14. 95	14. 80	14. 70	14. 70
	RATE OF COMBUSTION.							
19	Pounds of coal consumed per hour,...	278. 292	234. 833	155. 208	226. 182	264. 750	222. 083	151. 542
20	Pounds of combustible consumed per hour,...	238. 375	201. 125	129. 667	136. 272	244. 333	205. 833	145. 250
21	Pounds of coal consumed per hour per square foot of grate-surface,...	15. 319	12. 927	8. 544	12. 450	14. 573	12. 225	8. 342
22	Pounds of coal consumed per hour per square foot of heating-surface,...	0. 679	0. 573	0. 379	0. 551	0. 646	0. 541	0. 370
23	Pounds of combustible consumed per hour per square foot of grate-surface,...	13. 122	11. 071	7. 138	7. 512	13. 4 0	11. 333	7. 996
24	Pounds of combustible consumed per hour per square foot of heating surface,...	0. 581	0. 491	0. 316	0. 332	0. 596	0. 502	0. 354
	VAPORIZATION.							
25	Total - Pounds of water vaporized from the temperature of 100 degrees Fahrenheit,...	48,675. 729	40,921. 053	26,926. 735	25,416. 787	51,719. 766	42,819 798	33,312. 877
26	Total - Pounds of water vaporized from the temperature of 212 degrees Fahrenheit,...	54,370. 976	45,711. 236	29,292. 468	28,391 447	57,768. 328	47,822. 802	37,205. 105
27	Economic - Pounds of water vaporized from 100 degrees Fahrenheit by one pound of coal,...	7. 288	7. 261	7. 041	5. 108	8. 140	8. 014	9. 160
28	Economic - Pounds of water vaporized from 100 degrees Fahrenheit by one pound of combustible,...	8. 08	8. 478	8. 428	8. 478	8. 820	8. 668	9. 556
29	Economic - Pounds of water vaporized from 212 degrees Fahrenheit by one pound of coal,...	8. 141	8. 111	7. 864	5. 709	9. 092	8. 972	10. 229
30	Economic - Pounds of water vaporized from 212 degrees Fahrenheit by one pound of combustible,...	9. 504	9. 472	9. 413	9. 472	9. 851	9. 681	10. 673

periments made in 1871, *with the machine-shop boiler of the United Sta*
ryland semi-bituminous coal, of the carboniferous period; also, of Queen

	ANTHRACITE.				WELSH ANTH
	From the Scranton mines of Pennsylvania.			From Queen Charlotte Island.	From Weste
	Maxim'm combustion.	Medium combustion.	Slow combustion.		Maxim'm combustion.	Mediu combu tion.
	March 8, 9 *a. m.*	*Jan.* 18, 10.30 *a. m.*	*Feb.* 20, 8.30 *a. m.*	*Jan.* 19, 3 *p. m.*	*Sept.* 11, 9 *a. m.*	*Sept.* noon
	24	24	24	22	24	24
	755.550	644.000	408.110	400.000	829.048	685.
	47,080.116	40,065.164	25,423.968	24 885.195	51,432.970	42,543.
	6,079	5,636.	3,725	4,976	6,354	5,330
	679	514	479	1,229	423	349
	279	295	134	749	67	50
	958	809	613	1 978	490	399
	5,721	4,827	3,112	2,998	5,804	4,940
	10.17	9.12	12.86	24.70	6.66	6.
	4.17	5.23	3.60	15 05	1.05	0.
	14.34	14.35	16.46	39.75	7.71	7.
	54.1	47.0	45.6	42.6	62.9	63.
	67.8	67 6	66.5	64.1	76.3	74.
	63.5	77.0	66.0	77.0	94.0	93.
	30.04	30.14	29.95	30.35	29.96	29.
above the atmosphere,	0.110	0.101	0.050	0.050	0.090	0.
	14.85	14.90	14.75	14.95	14.80	14.
	278.292	214.833	155.208	226.182	264.760	222.
	238.375	201.125	129.667	136.272	244.343	205.
	15.319	12.927	8.544	12.450	14.573	12.
	0.679	0.573	0.379	0.551	0.646	0.
urface,	13.122	11.071	7.138	7.512	13.4 0	11.
g surface,	0.581	0.491	0.316	0.332	0.596	0.
grees Fahrenheit,	48,675.729	40,921.053	26,726.735	25,416.787	51,719.766	42,819
grees Fahrenheit	54,370.976	45,711.236	29,292.468	28,393 447	57,768.328	47,822.
eit by one pound of coal,	7.288	7.201	7.041	5.108	8.140	8.
it by one pound of combustible,	8. 08	8.478	8.428	8.478	8.820	8.
eit by one pound of coal,	8.141	8.111	7.864	5.709	9.092	8.
it by one pound of combustible,	9.504	9.472	9.413	9.472	9.851	9.

he United States Navy Yard at Mare Island, California, on the economic and potential vaporization also, of Queen Charlotte Island anthracite, and of Australian brown coal, of the cretaceous period.

WELSH ANTHRACITE.			SEMI-BITUMINOUS COAL.			AUSTRALIAN BROWN COAL.					
From Western Wales.			From the Cumberland mines of Maryland.			From the mines of New South Wales, near Sidney.					
						First Sample.			Second Sample.		
Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.
Sept. 11, 9 *a. m.*	*Sept.* 8, noon.	*Sept.* 12, 2 *p. m.*	*Feb.* 9, 9.30 *a. m.*	*Feb.* 10, 1.30 *p. m.*	*March* 1, 1 *p. m.*	*Feb.* 16, 9 *a. m.*	*Feb.* 17, 1.30 *p. m.*	*March* 6, 9 *a. m.*	*June* 22, 4 *p. m.*	*July* 6, 10 *a. m.*	*June* 30, 1 *p. m.*
24	24	24	24	24	24	24	24	24	24	24	24
829.048	685.622	531.635	950.910	701.560	461.900	945 000	640.460	434.380	843.110	569.162	408.108
51,432.970	42,543.018	31,006.141	59,183.030	43,665.019	28,786 097	58,854.463	39,8?5.475	27,069.778	52,466.779	35,430.467	25,362.859
6,354	5,330	3,?37	7,490	5,270	3,456	8,602	5,030	3,528	8,360	5,280	3,600
423	340	115	506	345	247	452	278	196	507	435	341
67	50	36	142	41	56	244	121	93	325	76	40
490	390	151	648	386	303	696	399	289	832	511	381
5,864	4,940	3,484	6,842	4,884	3,153	7,906	4,631	3,239	7,528	4,769	3,219
6.66	6.38	3.16	6.76	6.55	7.14	5.25	5.51	5.55	6.06	8.24	9 47
1.05	0.96	0.99	1.89	0.78	1.62	2.84	2.41	2.64	3.89	1.44	1.11
7.71	7.34	4.15	8.65	7.33	8.76	8.09	7.92	8.19	9.95	9.68	10.58
62.9	63.4	68.2	47.6	40.3	55.0	48.6	44.7	51.6	57.5	60.5	61 3
75.3	74.5	80.8	67.8	69.4	70.0	71.2	72.1	63 1	73.8	72.4	74.7
94.0	93.0	90.0	74.0	72.0	62.0	68.5	69.0	62.5	75.0	7z.5	84.0
29.96	29.90	29.91	30.10	30.08	29.95	30.27	30.23	29.95	29.94	30.02	29.84
0.090	0.025	0.015	0.127	0.090	0.050	0.124	0.063	0.050	0.12	0.036	0.027
14.80	14.70	14.70	14.90	14.85	14.75	14.98	14.90	14.75	14.82	14.77	14.67
264.750	222.083	151.542	312.083	219 583	144.000	358.417	209.583	147.000	348.333	220.000	150.000
244.333	205.833	145.250	285.083	203.500	131.390	329.417	192.958	134.958	313.667	198.709	134.125
14.573	12.225	8.342	17.179	12.087	7.927	19.729	11.537	8.092	19.174	12.110	8.257
0.646	0.541	0.370	0.761	0.535	0.354	0.874	0.511	0.360	0.850	0.537	0.366
13.4 0	11.333	7.996	15.693	11.202	7.23?	18.133	10.622	7.4 9	17.266	10.938	7.383
0.596	0.502	0.354	0.695	0.498	0.329	0.803	0.470	0.329	0.765	0.485	0.327
51,719.766	42,819 798	33,312.877	60,612.121	44,800.501	29,801 859	60,575.867	41,033.636	28,024.967	53,685.082	36,335.444	25,739.932
57,768.328	47,822.802	37,205.105	67,707.317	50,012.352	33,285.508	67,672.150	45,836.989	31,300.902	59,965.258	40,583.628	28,746.496
8.140	8.044	9.160	8.092	8.501	8.623	7.042	8.158	7.943	6.421	6.882	7.150
8.820	8.668	9.556	8.859	9.173	9.452	7.662	8.861	8.652	7.131	7.619	7.996
9.092	8.972	10.229	9.040	9.460	9.631	7.867	9.113	8.872	7.173	7.686	7.985
9.851	9.681	10.673	9.896	10.246	10.557	8.560	9.898	9.664	7.966	8.509	8.930

EXPERIMENTS ON VARIOUS COALS OF THE CARBONIFEROUS AND CRETACEOUS PERIODS,

To Ascertain their Relative Potential and Economic Vaporizations. Made by Chief Engineer B. F. ISHERWOOD, *U. S. Navy, at the Mare Island Navy Yard, California, in* 1871.

(Continued from page 39.)

EXPLANATION OF TABLES NO. 1 AND NO 2, CONTAINING THE DATA AND RESULTS OF THE EXPERIMENTS MADE ON VARIOUS COALS AND ON COKE, AT THE MARE ISLAND NAVY YARD, CALIFORNIA, TO DETERMINE THEIR POTENTIAL AND ECONOMIC VAPORIZATION.

In the following tables, Nos. 1 and 2, will be found the observed data and calculated results of the experiments made on various coals with the boiler of the machine shop engine at the Mare Island Navy Yard, California, and on coke, to determine their relative potential and economic vaporizations. The division into two tables is merely for convenience; each column contains the record of an experiment, while, for facility of reference, the quantities are arranged in groups with their lines numbered. Both groups and lines are the same in both tables. The heading of the columns are so full as not to require explanation.

Line 1 contains the exact date at which each experiment commenced.

Total quantities.—Line 2 contains the exact duration of each experiment in hours; that is to say, the time which elapsed from the first firing of the coal to the withdrawal of the coal from the furnace.

Line 3 contains the number of cubic feet of water of the temperature given on line 15, with the barometer as given on line 16, that was vaporized under the pressure given on line 18, during the time given on line 2. This quantity was ascertained by measurement in two wooden tanks lined with sheet-lead, and each containing exactly 164 cubic feet.

Line 4 contains the number of pounds of water of the temperature given on line 15, that was vaporized under the pressure given on line 18, during the time given on line 2. This quantity was ascertained by multiplying the number of cubic feet on line 3 by the weight in pounds of a cubic foot of water of the temperature given on line 15.

Line 5 contains the total number of pounds of coal consumed during the time on line 2. This quantity was ascertained by carefully weighing on a tested Fairbanks' platform-scales, all the coal thrown into the furnace during the time on line 2, and deducting therefrom

the unconsumed coal picked from the fire after its withdrawal from the furnace and wetting out.

Lines 6 and 7 contain, respectively, the total number of pounds of ash and clinker from the weight of coal consumed, as given on line 5. These quantities were ascertained by carefully hand-picking the refuse from the coal, dividing it into ash and clinker, and weighing them separately in the dry state on the same scales and in the same manner as described for the coal.

Line 8 contains the total number of pounds of ash and clinker given by the coal. This quantity is the aggregate of those on lines 6 and 7.

Line 9 contains the total number of pounds of combustible consumed; that is to say, the total number of pounds of what remained of the coals after deducting their ash and clinker. It, of course, includes the incombustible nitrogen and water of the coal, as well as the combustible carbon, hydrogen, oxygen and sulphur. This quantity is the remainder of that on line 5 after subtracting that on line 8. It is properly the gasified portion of the coal.

Line 10 gives the proportion of the coal which consisted of ash; and line 11 gives the proportion of the same which consisted of clinker. These quantities are, respectively, the per centum which the quantities on lines 6 and 7 are of the quantity on line 5.

Line 12 gives the proportion of coal which consisted of the aggregate ash and clinker. This quantity is the sum of those on lines 10 and 11, or it is the per centum which the quantity on line 8 is of the quantity on line 5.

Pressures and temperatures.—Line 13 contains the mean temperature in degrees Fahrenheit during the time, on line 2, of the atmosphere external to the boiler-house, taken in the shade by an ordinary mercurial thermometer, at the end of every hour.

Line 14 contains the mean temperature in degrees Fahrenheit during the time on line 2, of the air within the boiler-house, taken in front of the boiler midway its height, and 12 feet distant, at the end of every hour, by an ordinary mercurial thermometer.

Line 15 contains the mean temperature in degrees Fahrenheit during the time on line 2, of the feed-water in the tanks, taken at the end of every hour by an ordinary mercurial thermometer kept constantly immersed in the tanks near their bottom. The feed-water was rain-water collected into a large brick cistern. It owed its high temperature (line 15) to the fact of the exhaust steam from the ma-

chine-shop engine being condensed by air-contact in an old tubular boiler arranged as an air-condenser, and discharging the water of condensation into the cistern from which it was first pumped into the measuring-tanks by a small steam-pump, and thence delivered by gravity into the boiler.

Line 16 contains the mean height during the time on line 2, of the barometer in inches of mercury, taken at the end of every hour by a tested aneroid barometer placed in the boiler house midway the height of the boiler and 12 feet distant.

Line 17 contains the mean pressure during the time on line 2, of the steam in the boiler, in fractions of a pound per square inch above the atmosphere, taken at the end of every hour by a mercurial siphon-gauge. As the vaporization was effected under the atmospheric pressure with a discharge-pipe of large diameter, the steam-pressure within the boiler was but very little in excess of the atmospheric pressure without.

Line 18 contains the mean pressure during the time on line 2, of the steam in the boiler, in pounds per square inch above zero. It is the sum of the pressures on lines 16 and 17, and is the total pressure under which the water was vaporized.

Rate of combustion.—Lines 19 and 20 contain respectively the number of pounds of coal and combustible consumed per hour during the time on line 2. These quantities were obtained by dividing respectively those on lines 5 and 9 by the number of hours on line 2.

Line 21 contains the number of pounds of coal consumed per square foot of *grate-surface* per hour. This quantity was obtained by dividing that on line 19 by 18⅛—the number of square feet of grate-surface in the furnace.

Line 22 contains the number of pounds of coal consumed per square foot of *heating-surface* per hour. This quantity was obtained by dividing that on line 20 by 410—the number of square feet of water-heating surface in the boiler.

Line 23 contains the number of pounds of combustible consumed per square foot of *grate-surface* per hour. This quantity was obtained by dividing that on line 20 by 18⅛—the number of square feet of grate-surface in the furnace.

Line 24 contains the number of pounds of combustible consumed per square foot of *heating-surface* per hour. This quantity was obtained by dividing that on line 20 by 410—the number of square feet of water-heating surface in the boiler.

Vaporization.—Total. Line 25 contains the total number of pounds of water that would have been vaporized by the total number of pounds of coal consumed (line 5) during the time on line 2, had the temperature of the water on entering the boiler been 100 degrees Fahrenheit instead of that on line 15, and had the pressure under which the water was vaporized been 14,687572 pounds per square inch corresponding to the standard atmospherical pressure of 29·0218 inches of mercury, instead of the experimental pressure on line 18. This quantity is calculated from that on line 4 by means of the known total heats of steam above zero Fahrenheit, due to the standard pressure and to the pressure on line 18, deducting therefrom respectively the total heats of the water above zero Fahrenheit at the experimental temperatures on line 15, and the standard temperature of 100 degrees Fahrenheit.

Line 26 contains the total number of pounds of water that would have been vaporized by the total number of pounds of coal consumed (line 5) during the time on line 2, had the temperature of the water on entering the boiler been 212 degrees Fahrenheit instead of that on line 15, and had the pressure under which the water was vaporized been 14,687572 pounds per square inch corresponding to the standard atmospherical pressure of 29·9218 inches of mercury, instead of the experimental pressure on line 18. This quantity is calculated in the same manner as that on line 25, with the substitution of the temperature 212 degrees Fahrenheit for that of 100 degrees.

Economic.—Lines 27 and 28 contain respectively the number of pounds of water vaporized from the temperature of 100 degrees Fahrenheit under the pressure of 29·9218 inches of mercury, by one pound of coal, and by one pound of combustible. These quantities are respectively the quotients of the division of that on line 25 by those on lines 5 and 9.

Lines 29 and 30 contain respectively the number of pounds of water vaporized from the temperature of 212 degrees Fahrenheit under the pressure of 29·9218 inches of mercury, by one pound of coal, and by one pound of combustible. These quantities are respectively the quotients of the division of that on line 26 by those on lines 5 and 9.

Results of the Experiments.

Rapidity of combustion.—The various coals experimented on differed greatly in their rates of combustion, other things equal. Of course, the experimental rates cannot be depended on as strictly ac-

TABLE No. 2.—*Containing the data and results of the experiments made in* 1871, *with the machine shop boiler of the United States N the Rocky Mountains, Wyoming Territory; from the Mount Diablo Mines, California; from Coose Bay, Oregon; from near Seattl Vancouver Island, British Columbia, all of the cretaceous period; and of retort coke made from the Nanaimo coal.*

Number of line.		From the Wahsatch Range of the Rocky M'tains, Wyoming Ter., 8 miles N.E. of Salt Lake.			From the Mount Diablo Mines, California.			N
		Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	
1	Date of commencing the experiment,	*Feb.* 24, 10 *a. m.*	*Feb.* 27, 9 *a. m.*	*Feb.* 28, 11 *a. m.*	*June* 26, *noon.*	*Aug.* 31, *noon.*	*July* 5, 9 *a. m.*	
	TOTAL QUANTITIES.							
2	Duration of the experiment, in hours,	24	24	24	24	24	11½	
3	Cubic feet of water vaporized from the temperature of the feed-water,	691.360	425	331.800	513.770	411.861	130.094	
4	Pounds of water vaporized from the temperature of the feed-water,	43,112.373	26,491.055	20,679.973	31,984.313	25,626.655	8,104.447	4
5	Pounds of coal consumed,	9,865	5,760	3,840	7,486	5,520	1,614	1
6	Pounds of ash from the coal,	896	593	454	773	495	166	
7	Pounds of clinker from the coal,	745	152	95	161	29	25	
8	Pounds of ash and clinker from the coal,	1,641	745	549	934	524	191	
9	Pounds of combustible consumed,	8,224	5,015	3,291	6,552	4,996	1,423	
10	Per centum of the coal in ash,	9.08	10.29	11.82	10.33	8.97	10.29	
11	Per centum of the coal in clinker,	7.55	2.64	2.47	2.15	0.53	1.55	
12	Per centum of the coal in ash and clinker,	16.63	12.93	14.29	12.48	9.50	11.84	
	PRESSURES AND TEMPERATURES.							
13	Temperature, in degrees Fahrenheit, of the external atmosphere,	46.3	51.2	51.6	59.3	64.5	63.8	
14	Temperature, in degrees Fahrenheit of the boiler room,	61.2	65.3	66.2	75.0	74.3	73.2	
15	Temperature, in degrees Fahrenheit, of the feed-water,	59.5	60.0	61.0	72.0	76.0	66.0	
16	Height of the barometer, in inches of mercury,	29.85	29.55	29.55	30.07	29.88	29.96	
17	Steam-pressure in the boiler, in fraction of a pound per square inch above the atmosphere,	0.100	0.027	0.027	0.046	0.035	0.026	
18	Steam-pressure in the boiler, in pounds per square inch above zero,	14.75	14.53	14.53	14.81	14.70	14.73	
	RATE OF COMBUSTION.							
19	Pounds of coal consumed per hour,	411.042	240.000	160.000	311.917	230.000	140.348	
20	Pounds of combustible consumed per hour,	342.667	208.958	137.125	273.000	208.167	123.739	
21	Pounds of coal consumed per hour per square foot of grate-surface,	22.627	13.211	8.807	17.170	12.661	7.728	
22	Pounds of coal consumed per hour per square foot of heating-surface	1.002	0.585	0.390	0.761	0.561	0.342	
23	Pounds of combustible consumed per hour per square foot of grate-surface,	18.862	11.502	7.548	15.027	11.459	6.811	
24	Pounds of combustible consumed per hour per square foot of heating surface,	0.836	0.509	0.335	0.666	0.508	0.302	
	VAPORIZATION.							
25	Total - Pounds of water vaporized from the temperature of 100 degrees Fahrenheit,	44,733.648	27,475.196	21,429.043	32,816.078	26,198.004	8,360.351	4
26	Total - Pounds of water vaporized from the temperature of 212 degrees Fahrenheit	49,962.718	33,680.209	23,928.765	36,654.288	29,258.939	9,337.438	4
27	Economic - Pounds of water vaporized from 100 degrees Fahrenheit by one pound of coal,	4.535	4.770	5.580	4.384	4.746	5.180	
28	Economic - Pounds of water vaporized from 100 degrees Fahrenheit by one pound of combustible,	5.439	5.479	6.511	5.009	5.244	5.875	
29	Economic - Pounds of water vaporized from 212 degrees Fahrenheit by one pound of coal,	5.065	5.327	6.231	4.896	5.309	5.785	
30	Economic - Pounds of water vaporized from 212 degrees Fahrenheit by one pound of combustible,	6.073	6.118	7.271	5.596	5.870	6.562	

1871, *with the machine shop boiler of the United States Navy Yard at Mare Island, California, California; from Coose Bay, Oregon; from near Seattle, on Puget Sound, Washington Terri tort coke made from the Nanaimo coal.*

BROWN COAL.

	From the Wahsatch Range of the Rocky M'tains, Wyoming Ter., 8 miles N.E. of Salt Lake.			From the Mount Diablo Mines, California.			From Coose Bay, Oregon.			From near Seattle of Puget Sound, entrance, Washi	
	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Mediu combustion.
	Feb. 24, 10 *a. m.*	*Feb.* 27, 9 *a. m.*	*Feb.* 28, 11 *a. m.*	*June* 26, *noon.*	*Aug.* 31, *noon.*	*July* 5, 9 *a. m.*	*June* 27, 2 *a. m.*	*Sept.* 7, 9 *a. m.*	*Jan.* 28, 4 *p. m.*	*Sept.* 5, 1 *p. m.*	*Sept.* 9 *a. m*
.....	24	24	24	24	24	11½	24	24	19¾	21	24
.....	691. 360	425	331. 800	515. 770	411. 861	130. 094	658. 000	409. 359	234. 850	725 000	429.
.....	43,112. 373	26,491. 055	20,679. 973	31,984. 313	25,626. 655	8,104. 447	40,961. 750	25,430. 156	14,597. 663	45,084. 859	26,703.
.....	9,865	5,760	3,840	7,486	5,520	1,614	11,040	5,520	2,000	11,445	5,520
.....	896	593	454	773	495	166	882	386	282	1,099	657
.....	745	152	95	161	29	25	970	247	114	278	51
.....	1, 641	745	549	934	524	191	1,552	660	396	1,337	708
.....	8, 224	5,015	3,291	6,552	4,996	1,423	9,488	4,860	2,504	16,068	4,812
.....	9. 08	10. 29	11. 82	10. 33	8. 97	10. 29	5. 27	6. 99	9. 72	9. 60	11.
.....	7. 55	2. 64	2. 47	2. 15	0. 53	1. 55	8. 79	3. 96	3. 93	2. 43	0.
.....	16. 63	12. 93	14. 29	12. 48	9. 50	11. 84	14. 06	11. 95	13. 65	12. 03	12.
.....	46. 3	51. 2	51. 6	59. 3	64. 5	63. 8	62. 2	61. 3	65. 2	61. 3	62.
.....	61. 2	65 3	66. 2	75. 0	74. 3	73. 2	77. 4	71. 8	79. 5	75. 4	74.
.....	59. 5	60. 0	61. 0	72. 0	76. 0	66. 0	79. 0	86. 5	83. 0	80. 0	73.
.....	29. 85	29. 55	29. 55	30. 07	29. 88	29. 96	30. 00	30. 50	29. 81	29. 90	30.
.....	0. 100	0. 027	0. 027	0. 046	0. 035	0. 026	0. 100	0. 031	0. 020	0. 125	0.
.....	14. 75	14. 53	14. 53	14. 81	14. 70	14. 73	14. 83	15. 00	14. 65	14. 80	15.
.....	411. 042	240. 000	160. 000	311. 917	230. 000	140. 348	460. 000	230 000	146. 835	545. 000	230.
.....	34 . 667	208. 958	137. 125	273. 0 0	208. 167	123. 739	395. 333	202. 500	126. 785	479. 429	200.
.....	22. 627	13. 211	8. 807	17. 170	12. 661	7. 726	25. 321	12. 661	8. 083	30. 000	12.
.....	1. 002	0. 585	0. 390	0. 761	0. 561	0. 342	1. 122	0. 561	0. 358	1. 329	0.
.....	18. 862	11. 502	7. 548	15. 027	11. 459	6. 811	21. 761	11. 147	6. 979	26. 396	11.
.....	0. 836	0. 800	0. 335	0. 669	0. 508	0. 302	0. 984	0. 404	0. 300	1. 169	0.
.....	44,733. 648	27,475. 196	21,429. 043	32,816. 078	26,198 004	8,360. 351	41,760. 804	25,749. 072	14,824 251	45,922. 511	27,373.
.....	49,962. 718	30,680. 209	23,928. 765	36,654. 2 8	29,258. 939	9,337. 438	46,646. 057	28,766. 070	16,559. 944	51,293, 091	30,580.
al,.....	4. 535	4. 770	5. 580	4. 384	4. 746	5. 180	3. 782	4. 665	5. 113	4. 012	4.
ustible	4. 439	5. 479	6. 511	5. 009	5. 244	5. 875	4. 401	5. 298	5. 922	4. 561	5.
al,.....	5. 065	5. 327	6. 231	4. 896	5. 309	5. 785	4. 225	5. 211	5. 710	4. 482	5.
ustible,	6. 073	6. 118	7. 271	5. 596	5. 870	6. 562	4. 916	5. 919	6. 613	5. 094	6.

d, California, on the economic and potential vaporization of brown coals from the Wahsatch Range of hington Territory; from Bellingham Bay, Washington Territory; and from the Nanaimo Mines of

COAL.									COKE.		
From near Seattle, at south end of Puget Sound, 70 m. from its entrance, Washington Ter'rv.			From Bellingham Bay, Washington Territory.			From the Nanaimo mines of Vancouver Island.			Made from the Nanaimo coal in the retorts of the San Francisco gas works		
Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.	Maxim'm combustion.	Medium combustion.	Slow combustion.
Sept. 5, 1 *p. m.*	*Sept.* 4, 9 *a. m.*	*Sept.* 6, 2 *p. m.*	*June* 20, 1 *p. m.*	*Sept.* 1, 2 30 *p. m.*	*June* 20, 1 *p. m.*	*Feb.* 13, 9.30 *a. m.*	*Feb.* 14, 1.30 *p. m.*	*March* 2, 3 *p. m.*	*August* 7, 9 *a. m.*	*August* 8, 11 *a. m.*	*August* 30, 9 *a. m.*
21	24	7	24	24	17	24	24	24	24	16¼	24
725 000	429. 000	92. 567	627. 000	434. 377	187. 320	667. 400	563. 230	358. 070	669. 300	326. 180	359. 930
45,084. 850	26,703. 671	5,756. 373	39,018. 243	27,023. 891	11,642. 388	41 558. 453	35,071. 872	22.314. 276	41,617. 950	20,277. 669	22,417. 671
11,445	5,520	1,070	10,225	5,520	2,326	8,021	5,512	3,580	6,900	3,442	3,720
1,099	657	144	1,774	787	509	554	532	213	419	226	285
278	51	14	733	272	168	487	205	240	551	263	203
1,337	708	158	2,507	1,059	667	991	737	452	970	489	480
16,068	4,812	912	7,716	4,461	1,649	7,030	4,775	3,128	5,930	2,953	3,231
9. 60	11. 90	13. 46	17. 35	14. 26	21 88	6. 91	9. 65	5. 92	6. 07	6. 54	7. 69
2. 43	0. 91	1. 30	7. 17	4. 92	7. 22	5 45	3. 72	6. 70	7. 99	7. 64	5. 46
12. 03	12. 83	14. 76	24. 52	19. 18	29. 10	12. 36	13. 37	12. 62	14. 06	14. 18	13. 15
61. 3	62. 2	67. 3	62. 1	63. 4	61. 3	48. 8	48. 1	54. 4	62. 6	62. 6	63. 8
75. 4	74. 6	74. 7	75. 0	74. 3	78. 0	68. 2	70. 6	70. 6	74. 4	76. 2	74. 2
80. 0	73. 0	80. 0	75. 0	77. 0	83. 5	70. 0	70. 0	62. 5	79 5	82. 0	68. 0
29. 90	30. 51	29. 90	30. 00	30. 50	29. 94	30. 16	30. 07	30. 00	30. 00	29. 96	29. 86
0. 125	0. 036	0. 025	0. 106	0. 031	0. 026	0. 100	0. 040	0. 026	0. 076	0. 036	0. 026
14. 80	15. 01	14. 70	14. 83	15. 00	14. 72	14. 90	14. 80	14. 75	14. 80	14. 74	14. 66
545. 000	230. 000	152. 857	426. 042	230. 000	136. 824	334. 208	229. 667	149. 167	287. 500	211. 815	155. 000
479. 429	200. 500	130. 286	321. 583	185. 875	97. 000	292. 917	198. 958	130. 333	247. 083	181. 722	134. 625
30. 009	12. 661	8. 414	23. 452	12. 661	7. 532	18. 307	12. 642	8. 211	15. 826	11. 606	8. 532
1. 329	0. 561	0. 373	1. 039	0. 561	0. 334	0. 815	0. 560	0. 364	0. 701	0. 517	0. 378
26. 396	11. 037	7. 172	17. 702	10. 232	5. 339	16. 124	10. 952	7. 174	13. 600	10. 003	7. 411
1. 169	0. 489	0. 318	0. 784	0. 453	0. 237	0. 714	0. 485	0. 318	0 602	0. 443	0. 328
45,922. 511	27,373. 108	5,863. 334	39,924. 204	27,601. 133	11,820. 875	42,716. 776	36,049. 032	23,101. 660	42,410. 607	20,616. 782	23,083. 966
51,293. 091	30,580. 777	6,548. 307	44,594. 676	30,835. 135	13,202. 268	47,717 156	40,264. 925	25,802. 095	47,370. 363	23,026. 525	25,780. 043
4. 012	4. 959	5. 480	3. 905	5. 000	5. 082	5. 326	6. 540	6. 453	6. 146	5. 990	6. 205
4. 561	5. 689	6. 429	5. 173	6. 187	7. 169	6. 076	7. 550	7. 385	7. 152	6. 982	7. 144
4. 482	5. 540	6. 120	4. 361	5. 588	5. 671	5. 949	7. 305	7. 207	6. 865	6. 690	6. 930
5. 094	6. 355	7. 180	5. 778	6. 912	8. 006	6. 788	8. 432	8. 249	7. 988	7. 798	7. 979

Vaporization.—Total. Line 25 contains the total number of pounds of w
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Rapidity of combustion.—The various coals experimented on differed greatly in their rates of combustion, other things equal. Of course, the experimental rates cannot be depended on as strictly ac-

curate, relatively, because the experiments being made at different times, the draught of the chimney was differently influenced by differences in the barometric and hygrometric conditions of the atmosphere, and by the movements of the air, all of which continually varied; still, they approximate accuracy sufficiently for practical purposes. The measure of the rate of combustion will be taken to be the number of pounds of the combustible portion of the coal consumed per hour per square foot of grate-surface (line 20, Tables Nos. 1 to 2); that is to say, the number of pounds of what remains of the coal after deducting its ash and clinker.

In the following table are exhibited these maximum rates, both absolutely and relatively. In the latter case, the maximum rate of combustion of anthracite is taken for unity, as that coal is generally used in the Navy and on the sea-board of the United States.

KIND OF COAL.	Maximum rate of combustion.	
	In pounds of the combustible portion of the coal per hour per sq. foot of grate-surface.	Relatively.
Anthracite of Pennsylvania	13·122	1·0000
Welsh anthracitic	13·450	1·0250
Coke from Nanaimo coal	13·600	1·0364
Mount Diablo brown coal	15·027	1·1451
Semi-bituminous coal of Maryland	15·693	1·1959
Nanaimo brown coal	16·124	1·2288
Australian brown coal (second sample)	17·266	1·3158
Bellingham Bay brown coal	17·702	1·3490
Australian brown coal (first sample)	18·133	1·3819
Rocky Mountain brown coal	18·862	1·4374
Coose Bay brown coal	21·761	1·6584
Seattle brown coal	26·396	2·0116

In rapidity of combustion, the brown coals exceed, on an average, the true coals about one-third.

Potential vaporization.—By the potential vaporization of the different kinds of coals, is meant the weight of water which these kinds will vaporize in the experimental boiler in a given time with the maximum rate of combustion, and without regard to the quantity of coal consumed or the economy of the vaporization. The measure of this vaporization is the quotient of the quantity on line 26 of Tables Nos. 1 and 2, divided by the quantity on line 2. It is given in the following table, both absolutely and relatively, taking that of the anthracite for unity.

KIND OF COAL.	Potential vaporization.	
	In pounds of water vaporized per hour from the temperature of 213 degrees Fahr.	Relatively.
Anthracite of Pennsylvania	2265·495	1·0000
Welsh anthracitic	2407·014	1·0624
Semi-bituminous coal of Maryland	2828·471	1·2489
Australian brown coal (first sample)	2819·673	1·2446
Australian brown coal (second sample)	2498·552	1·1029
Rocky Mountain brown coal	2081·780	0 9198
Mount Diablo brown coal	1527·260	0·6741
Coose Bay brown coal	1943·585	0·8579
Seattle brown coal	2442·528	1·0781
Bellingham Bay brown coal	1858 111	0·8202
Nanaimo brown coal	1988·215	0 8776
Coke from Nanaimo coal	1973·765	0·8712

In potential vaporization the brown coals are inferior, on an average, to the true coals about one-seventh.

Economic vaporization.—By the economic vaporization of the different kinds of coal, is meant the number of pounds of water which one pound of these kinds will vaporize in the experimental boiler. This vaporization varies in boilers of the usual proportion of heating-surface to grate-surface with the rate of the combustion, and, as the experimental rates were three in number, namely, the maximum, the medium and the slow, there will be found in the following table the results of all three. Now, as the proportion of ash and clinker in a coal is, in great measure, the result of accidental admixture, and constantly variable, the pound of combustible, or that portion of the coal which remains after deducting the ash and clinker, will be taken to represent the pound of coal; and the number of pounds of water vaporized by it from the temperature of 212 degrees Fahrenheit under the pressure of 29·92 inches of mercury (line 30, Tables Nos. 1 and 2), will be taken to represent its economic effect.

At the maximum rate of combustion, the economic vaporization by the brown coals was, on an average, 35 per centum less than that by the true coals.

At the medium rate of combustion, the economic vaporization by the brown coals was, on an average, 26 per centum less than that by the true coals.

At the slow rate of combustion, the economic vaporization by the brown coals was, on an average, 24½ per centum less than that by the true coals.

KIND OF COAL	Vaporization of water from the temperature of 212 degrees Fahrenheit under the pressure of 29·92 inches of mercury, by one pound of combustible.					
	Maximum combustion.		Medium combustion.		Slow combustion.	
	Pounds of water.	Relatively.	Pounds of water.	Relatively.	Pounds of water.	Relatively.
Anthracite of Pennsylvania	9·504	1·0000	9·472	1·0000	9·413	1·0000
Welsh anthracitic	9·851	1·0365	9·681	1·0221	10·673	1·1338
Semi-bituminous coal of Maryland	9·896	1·0412	10·246	1·0817	10·557	1·1215
Australian brown coal (1st sample)	8·560	0·9007	9·898	1·0450	9.664	1·0267
Australian brown coal (2d sample)	7·966	0·8382	9·509	0·8983	8·930	0·9487
Rocky Mountain brown coal	6·073	0.6390	6·118	0·6450	7·271	0·7724
Mount Diablo brown coal	5·596	0·5888	6·856	0·6182	6·562	0·6971
Coose Bay brown coal	4·916	0.5173	5·919	0·6249	6·613	0·7025
Seattle brown coal	5·094	0·5360	6·355	0·6709	7·180	0·7628
Bellingham Bay brown coal	7·778	0·6979	6·912	0·7297	8·006	0·8505
Nanaimo brown coal	6·788	0·7142	8·432	0·8900	8·249	0·8763
Coke from Nanaimo coal	7·988	0·8405	7·798	0·8233	7·979	0·8477

From the above it appears that the brown coals, relatively to the true coals, gave a considerably higher economic vaporization the slower the rate of combustion. In other words, the economic vaporization was less decreased by increased rapidity of combustion with the true coals than with the brown ones. The former are, therefore, disproportionately better adapted for use when a minimum boiler is employed to produce a given quantity of steam in a given time. For example, with the slow rate of combustion (about 7·109 pounds of combustible consumed per square foot of grate-surface per hour), the brown coals were 23½ per centum inferior in economic vaporization to the true coals; with the medium rate of combustion (about 11·045 pounds of combustible consumed per square foot of grate-surface per hour), this inferiority became 26 per centum; and with the maximum rate of combustion (about 18·909 pounds of combustible consumed per square foot of grate-surface per hour for the brown coals, and 14·088 pounds for the true ones), the inferiority rose to 35 per centum.

In the two former cases the rate of combustion was nearly the same with both the brown and the true coals; but, in the latter case, it was considerably more with the brown coal than with the true coal, and a portion of the increased inferiority in this case must be credited to the difference in the rates of the maximum combustion of the two kinds of coal.

The economic vaporization given by the coke was, for the slow and medium rates of combustion, about 5½ per centum less than that given by the coal from which it was made; while, for the maximum rate of combustion, the coke gave about 17⅔ per centum greater economic vaporization than the coal from which it was made.

(To be continued.)

THEORY OF CONTINUOUS BEAMS.

By Jos. P. Frizell, C. E.

Continued from page 45.

We have already seen that in a beam supported only at its extremities the bending moment M is null at the supports, and increases toward the centre, becoming a maximum at a certain point called the breaking point, whose position depends upon the distribution of the load. In such a case the lower fibres are exposed to extension and the upper ones to compression throughout the entire length of the beam.

Consider, now, a beam supported at several points, A_1 A_2 A_3. At A_1 the upper fibres are extended and the lower ones compressed, and the bending moment diminishes from A_1 towards A_2. At b_1, supposed to be a breaking point, the lower fibres are extended, the upper compressed, and the bending moment diminishes from b_1 towards A_1. It is apparent that between A_1 and b_1 there must be a point, O_1, where compression changes to extension, and *vice versa*. At this point there is neither extension nor compression upon any fibre in the section of the beam. The portion O_1 O_2 rests at O_1 O_2 precisely as it would upon two points of support. The portion P_1 O_1 is in the same condition as a simple beam resting at A_1 and loaded at one extremity with the weight P_1, and at the other with the weight of the portion O_1 b_1.

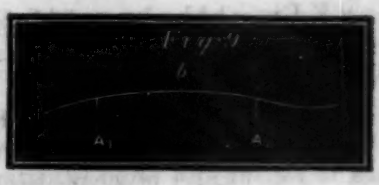
It appears, therefore, that a beam resting at several points resolves itself into a number of simple beams, either resting at their extremities, or resting each at a single point and sustaining loads at their extremities.

In speaking of the properties of the breaking point to an eminent

engineer and bridge constructor, I was met by the objection that in bridges of modern construction no such point exists, such bridges being made capable of offering a resistance proportional to the strain, at all points under an uniform load. To remove any such source of misapprehension let it be explained that I use the term "breaking point" as a convenient term, and one suggested, by the nature of the case, to indicate the point where the forces tending to produce rupture by bending are greatest, not necessarily the point where rupture is most likely to occur, though the latter would be the case in a bridge of uniform strength.

The simple beams supported at a single point are invariably in the condition shown at Fig. 8, so weighted as to exactly balance at the supporting point. Thus, if the portion O_2 O_3, Fig. 7, were separated from the rest of the beam at O_2 O_3, and loaded at these points with weights equal respectively to O_2 b_1, O_3 b_2, it would have no tendency to incline to the right or left. Such a tendency would presuppose a bending strain at O_2 and O_3, which is contrary to the supposition. In each of the beams so supported, therefore, the moments, with reference to the supporting point, of the forces tending to turn the beam to the right are equal to those of a contrary tendency, and the point of support is a breaking point, or point of maximum bending strain. O_1 O_2 O_3, &c., are called Inflection Points.

An increase of the weight between P_1 and A_1, and between A_2 and A_3, would cause the inflection points O_1 O_2 to approach one another. If this increase of weight is carried far enough, the three points O_1 O_2 b_1 will come together, and this portion of the beam will assume the form shown at Fig. 9. b_1, in the case supposed, resembles the inflection point in that the bending moment is there a minimum, though not necessarily 0. It also resembles the breaking point in that the weight between A_1 and b_1 falls upon A_1, and that between b_1 and A_2 falls upon A_2.



It is evident that the weight upon a continuous beam may be so distributed as to remove the pressure altogether from one or more of

the points of support, showing how futile is the assumption, sometimes made in the case of pillars supporting continuous beams, that the weight upon the beam is uniformly distributed among the pillars.

Let $O_1\ O_4$, Fig. 10, be a beam resting upon the supports $A_1\ A_2$. Let w represent the weight of the beam per linear foot, including, if necessary, any uniformly distributed load, l the distance, $A_1\ A_2$, l_1 the distance of the inflection point from the supporting point. Suppose the beam to project beyond the supporting points at each end a distance l_1, and to sustain a load at each extremity equal to $\overline{O_2\ b_1}\ w = \overline{b_1\ O_3}\ w = (\frac{1}{2}\ l - l_1)\ w$. This case corresponds to what is ordinarily given in the books as a beam fixed at both ends and loaded uniformly. The portion $O_2\ O_3$ is a simple beam, resting at its extremities and sustaining an uniformly distributed load. The portions $O_1\ O_2$, $O_3\ O_4$, are simple beams, resting at their centres, and sustaining equal weights at their extremities, in addition to an uniformly distributed load. The tangent at the supporting point will therefore be horizontal. The resting point A_1 being assumed as the origin of co-ordinates, the equation of the elastic curve will be

$$E\ I \frac{d^2 y}{d x^2} = \tfrac{1}{2}\ (l + l_1 - x)^2\ w + (l + l_1 - x)\ (\tfrac{1}{2}\ l - l_1)\ w - (l - x)\ l\ w$$

$$= \tfrac{1}{2}\ l\ l_1\ w - \tfrac{1}{2}\ l_1^2\ w - \tfrac{1}{2}\ l\ x\ w + \tfrac{1}{2}\ x^2\ w. \quad \text{Integrating}$$

$$E\ I \frac{d y}{d x} = \tfrac{1}{2}\ l\ l_1\ x\ w - \tfrac{1}{2}\ l_1^2\ x\ w - \tfrac{1}{4}\ l\ x^2\ w + \tfrac{1}{6}\ x^3\ w + c \qquad (7)$$

Since the tangent at the supporting point is horizontal $\frac{d y}{d x} = 0$ when $x = 0$ whence $c = 0$. A second integration gives, observing that $y = 0$ when $x = 0$,

$$E\ I\ y = \tfrac{1}{4}\ l\ l_1\ x^2\ w - \tfrac{1}{4}\ l_1^2\ x^2\ w - \tfrac{1}{12}\ l\ x^3\ w + \tfrac{1}{24}\ x^4\ w \qquad (8)$$

When $x = l$, $y = 0$ whence $\frac{1}{4}\ l^3\ l_1 - \frac{1}{4}\ l^2\ l_1^2 - \frac{1}{12}\ l^4 + \frac{1}{24}\ l^4 = 0$. Therefore,

$$l_1^2 - l\ l_1 = -\tfrac{1}{3}\ l^2 + \tfrac{1}{6}\ l^2 = -\tfrac{1}{6}\ l^2 \qquad \text{or}$$

$$l_1 = \tfrac{1}{2}\ l \pm \sqrt{(\tfrac{1}{4} - \tfrac{1}{6})\ l^2} = \frac{l}{2}\ (1 \pm \sqrt{\tfrac{1}{3}}) = 0{\cdot}2112\ l$$

* The double value of l_1 indicates that the properties of the inflection point belong to o_3 as well as o_2.

Having found the value of l_1 we may treat each of the portions O_1 O_2, O_2 O_3, O_3 O_4, as a simple beam, and determine its deflection for a given load, or the load corresponding to a given deflection, or the load corresponding to the greatest allowable bending moment.

We may now suppose the beam to be extended across a third point of support A_3, extending a distance l_1 beyond it, and sustaining a weight at O_6 equal to that at O_4 Fig. 10. The weight at O_4 will be replaced by its equivalent $(\frac{1}{2}\,l - l_1)\,w$, O_4 will become an inflection point, and the strains in the portion O_1 O_4 will be in no respect altered. O_4 O_6 will be in the same condition as O_2 O_4 in Fig. 10.

Proceeding in this manner, we may, so to speak, *form* out of simple beams a continuous beam of any desired length, resting upon equidistant supports, and loaded uniformly. The method has little practical value, however, except to show the advantage of the continuous over the disconnected girder. In the continuous girder the maximum value of the bending moment occurs at the supporting points, and, for the case supposed, is represented by

$$\tfrac{1}{2}\,l_1^2\,w + l_1\,(\tfrac{1}{2}\,l - l_1)\,w = \tfrac{1}{2}\,(l\,l_1 - l_1^2)\,w$$
$$= \tfrac{1}{2}\,(0{\cdot}2112\,l^2 - (0{\cdot}2112\,l)^2)\,w = 0{\cdot}0833\,l^2\,w$$

In a discontinuous beam sustaining the same weight w per linear foot, and having the same distance l between bearings, the maximum value of the bending moment occurs at the centre, and is represented by $\frac{1}{2}\,l \times \frac{1}{2}\,l\,w - \frac{1}{2}\left(\frac{l}{2}\right)^2 w = \frac{1}{8}\,l^2\,w = 0{\cdot}125\,l^2\,w$, or, the maximum bending strain is 50 per cent. greater in the latter beam than in the former.

(To be continued.)

The Dissociation of Carbonic Acid.—M. A. Thenard states* that, if a slow current of carbonic acid gas is passed through one of Houzeau's apparatus for the preparation of ozone with the aid of an electric current, the gas is decomposed into carbonic oxide and oxygen, and that the latter is strongly ozonized.

* Chem. News, from Comptes Rendus, May 13, 1872.

Chemistry, Physics, Technology, etc.

TERRESTRIAL MAGNETISM.

By Richard Owen, M.D., LL.D., of Indiana State University.

In the March number of this Journal some experiments were detailed, at the close of an article on Terrestrial Magnetism, with the promise that if subsequent investigations either confirmed or refuted the conclusions presented, the results should be given in a subsequent number. Those experiments were designed to investigate the subject of

Magnetic Springs.

On repeating several times the attempt to render nails and other iron or even steel instruments magnetic by leaving them a definite time in water in which magnets were or had been immersed, I found that, in these subsequent experiments, the water did not render the steel magnetic, and that it only became so when the implement came, at least for a second or two, in contact with the bars, while the cut nails or even wrought-iron nails required contact during several hours before they acquired permanent polarity. As, however, the manner of rendering iron or steel magnetic which I found efficacious differs somewhat from the plan usually laid down, and gave me uniformly results that are not detailed in such recent works as that of Miller in his Chemical Physics (Article Magnetism), perhaps some description of the method pursued and of the results obtained may be new at least to a portion of the readers of the "Journal."

Results Obtained with Bar Magnets on Steel Rods or Wire.

Usually steel bars or needles are rendered magnetic by having bar magnets placed at a given angle, with their opposite ends centrally over the bar to be magnetized, and drawn a number of times in that position to the ends, then turning the lower side of the bar up, the operation is repeated about the same number of times. Or we may thus use a horse-shoe magnet, drawing the north end say from centre to the end on our right, the south end from centre to the end on our left, or *vice versa*. Some authors speak of bars being rendered magnetic by being held on a block or anvil, with a slope equal to that of the dipping needle, and then being repeatedly struck with a light hammer, or by being placed alongside of a magnet for a given time.

In my experiments I found that if I placed small steel bars, say bradawls without handles, between two magnetic parallel bars (with the north end of one facing the south of the other), the awls being about $\frac{1}{2}$ or $\frac{3}{4}$ of an inch from the end of the bars, one or two seconds sufficed to render the steel bradawls so magnetic that they retain this power after two months, and probably will retain it permanently. The power thus instantly imparted enables a quarter-inch bradawl even yet, at the close of two months, to cause a clinometer compass needle to diverge 90°, or, in other words, to stand east and west when either end is presented, one attracting the north end of the needle, the other the south. The power again in a $\frac{1}{4}$-inch bradawl is sufficient to raise readily an 8-oz. tack, and even an additional 4-oz. tack, if carefully touched, alongside the other.

This mode of indicating the power is not as accurate as other methods pointed out by science, but may suffice for the elucidation of the present object.

Results with Iron Articles, such as Cut Nails and Horse-Shoe Nails.

A common tenpenny nail, when left between the bar magnets in the manner above prescribed for the bradawl, was found, after four or five hours' contact, sufficiently magnetic to deflect the same needle readily at least 75°, and to possess polarity which has continued unabated for one month. Thinking this permanent polarity in the cut nail must either be due to a certain amount of carbon in the iron (impeding the exit of the peculiar mode of motion termed magnetism), or to some modification of the crystalline structure when the soft iron was cut by machinery, I next experimented with nails flexible enough to clinch, such as those sold by hardware merchants, and lastly with horse-shoe nails from the blacksmith's shop. Still the results were the same, the horse-shoe nails after a few hours' contact, now, at the end of several weeks, possess decided polarity, and deflect the needle many degrees, although they do not raise even a 4-oz. tack from the table.

Before contact none of these nails exhibited the least polarity, attracting the north end of the needle or the south end of the needle with either their points or ther heads indiscriminately; but after contact they attract, say the north with the point of the nail, and repel the south; again, they attract the south with the head of the nail and repel the north. The head of the nail can, of course, be made to

acquire either polarity by noticing which pole of the bar magnet we place it against.

Recent Volcanoes and Earthquakes.

It is interesting to remark that recent seismographic disturbances, as well as those of former periods accurately recorded, can nearly all be assigned to a belt of activity not far on each side of a great circle of the earth, alluded to but not detailed in my article on Terrestrial Magnetism in the October number of this Journal for 1871.

When the north pole of the globe is elevated about 23½°, and St. Thomas' Island, on the equator, west of Africa, is placed under the brazen meridian, we shall find that the horizon now marks a great circle, on each side of which, at no great distance, a large majority of the linear and some central volcanoes can be found.

Commencing at the north, and following the belt east, we have the volcanoes of the Karibs and Kamtchatka, those of Japan, then those of Sumatra and the East Indian archipelago, New Amsterdam and St. Paul Islands, Sandwich Land and Georgia Isle, nearly the whole of the Andes in South and Central America, part of the Rocky Mountains, and finally the Aleutian volcanic region. Under the brazen meridian, which is at right angles to the above, we find another important volcanic belt, thus: Passing north from the equator through Africa, we soon reach the volcanic regions of Algiers, Sicily and Italy, and no great deviation from the great circle brings us through the highest portions of Europe (Mt. Blanc, &c.), not far from the extinct volcanic region of Auvergne, and subsequently of the Eifel, to the regions in Scandinavia where at the present day evidences of gradual upheaval or rise are to be found. Thence, passing the north pole, we find the brazen meridian almost marking the powerful volcanoes of the Sandwich Islands.

Nearly all the localities of volcanic or seismic energy not within the above zones may be found under the phases of the ecliptic or their secondaries, pointed out in the paper read before the A. A. A. S., and published in the October number of this Journal. A few earthquake regions not embraced in the above will be found in the zones belonging to two great circles defined in the same paper as passing through St. Thomas' Island, on the equator, west of Africa, where the terrestrial and magnetic equators intersect. These two great circles respectively girdle the globe at a distance of about 15° each side of the north and south geographical poles. To exhibit these facts more

clearly, let us take the seismographic tables given in the Earthquake Catalogue of Messrs. R. and I. W. Mallet. As the work is so extensive, I concluded to go back exactly one century, and take the chief phenomena for ten years, then to go back half a century and take again ten years, marking in brackets all the localities which did not come within some of the above dynamic zones. Omitting only a few unimportant places, the following is a list of earthquakes and volcanic action, taken from Mallet's Catalogue:

BEGINNING ONE CENTURY BACK AND CONTINUING TEN YEARS.

1772. Java, France, Lapland, Padau, Lisbon, Algiers, Genoa, Padau, Pay, Tyrol, Pyrenees, Hungary, [Caucasus,] Morocoo, Rhone.

1773. Claussages, (Dept. Drome in France,) Norway, Lisbon, Madrid, Gibraltar, Tangiers, Hungary, Algiers, New Zealand, Corfu, Claussages, Gautemala, Luxembourg, Bergen and Norway generally, Copiapo in Chili.

1774. Martinique, Parma, Padua, Berne, [Cayenne,] Altdorf, Strasbourg.

1775. Padau, Modena, Norway, Sweden, Turin, [Island of Amboyna,] Sweden, [Azores,] Gautemala, Corsica, England, Toulouse, Iceland.

1776. Bretagne, [Rhode Island,] Malta, Trieste, La Rochelle, Padua, [Guadaloupe,] Manheim, Finland, [Scotland.]

1777. Leghorn, Lucerne, Hungary, Naples, Calabria, Padua, Malaga, Messina, [England,] Lisbon, Florence, Sweden.

1778. Leghorn, Rome, Manheim, Parma, Aleppo, Grenada, Padua, Smyrna, Cadiz, Grenada, Trieste, Padua, Normandy.

1779. Caraccas, Orizaba, Island of Candia, Smyrna, Constantinople, Rouen, Sweden, Vesuvius, Bergen, Naples, Padua, [Vienna,] Padua.

1780. Malta, Java, Auvergne, Padua, Coblentz, [Persia,] Etna, Calabria, Padua, Genoa, [Wales,] Norway, Candia, Padua, [England,] [Armenia,] Bologna, Padua, Etna.

1781. Padua, Lisbon, Florence, Padua, Milan, Jamaica, Hungary.

1782. Padua, La Rochelle, Hungary, Sweden, [Guadaloupe,] [England,] Norway.

DATING FROM HALF A CENTURY BACK AND CONTINUING TEN YEARS.

1822. Naples, Hungary, Sweden, Switzerland, Etna, [Scotland,] Sicily, Hungary, Calabria, Granada, Siberia, Croatia, Sweden, Cadiz,

Aleppo, Vesuvius, Copiapo in Chili, Coquimbo, Concepcion, Valparaiso, Strasbourg, Mayence, [Island Grenada, W. I.,] Hungary, Java.

1823. Norway, Chili, Spain, Norway, Sweden, St. Petersburg, Ceylon, Moldavia, Palermo, Norway, Madras, Ceylon, Palermo, Messina, Is. Martinique, Norway, Wallachia, Aleppo, Sicily, [Lake Erie,] Palermo, Turkey, Antioch in Syria, Chili, Iceland, Tuscany, Ragura, Palermo, [Martinique,] Norway, Chili, Sweden, Calcutta.

1824. Macao in China, Cuba, Norway, Bohemia, Chili, Bohemia, Norway, Saxony, Sardinia, Norway, Siberia, Palermo, Tuscany, Altai Mountains, Norway, Jamaica, Persia, St. Domingo, St. Helena, [Shiraz in Persia,] Chili, [England,] Holland, Siberia, Norway, [Guadaloupe, Martinique,] Philippine Islands, Mayence, [Martinique,] Norway, Palermo, Hamburg, [Persia.]

1825. Alsace, Florence, Norway, Ionian Isles, Iceland, Marseilles, Altai Mountains, Norway, Tuscany, Honduras, Algiers, Carraccas, Norway, Java, Sicily, Calabria, Mexico, Smyrna, Chili, Algiers, West Indies, Cairo in Egypt, Genoa, Demarara, Trinidad, Naples, Kamtchatka, Haiti, [Schiraz,] Geneva, Strasbourg, Manheim.

1826. [Martinique,] Norway, Naples, Constantinople, Smyrna, Lapland, Norway, Italy, Styria, Palermo, Chili, [Martinique,] Spain, Norway, Smyrna, Santa Fe de Bogota, Naples, Venice, Tyrol, Jamaica, Norway, Chili, Hungary, [Georgia, U. S.,] Naples, Norway, Granada, Tyrol.

1827. Calcutta, Crimea, Naples, Norway, Palermo, Pesaro, Tyrol, Norway, Mexico, Peru, Chili, [Martinique,] Palermo, Chili, Norway, Lisbon, [Martinique,] Moldavia, [Caucasus,] Norway, Corsica, Santa Fe de Bogota, Siberia, Berne, Norway, [Martinique,] Sweden, Iceland, Venice.

1828. Naples, Tabasco, Norway, Swabia, Philippine Islands, Belgium, [Washington, D. C.,] Norway, West Indies, Calabria, Belgium, Martinique, Peru, Chili, Rome, Berlin, Berne, [Scotland,] Chili, Smyrna, Sicily, Chili, Hindostan, [Caucasus,] Switzerland, Chili, [Caucasus,] Chili, Palermo, Murcia, (Spain,) Calcutta, Chili, Palermo, Genoa, Turin, Columbia, (S. A.,) [Martinique,] Frankfort on Maine, Belgium, Georgia, (U. S.,) Berne, Vesuveus, Spain, N. S. Wales.

1829. Berne, Celebes, Spain, Caucasus, Greece, [Martinique,] Iceland, Smyrna, Stockholm, Irkutsk, Sweden, Jamaica, Murcia, St. Domingo, Macedonia, Greece, Sweden, [Tennessee, (U. S.,)] Macedonia, Thrace, City of Mexico, Constantinople, Scutari, Jamaica, Riesengebioge, West Indies, Murcia, Paris, Hungary, Denmark, New

South Wales, Frankfort, [Martinique,] Switzerland, Spain, Chili, Altai, Moldavia, Columbia, (S. A.,) Naples.

1830. Hungary, Berne, [Caucasus,] [Astrakan,] [Martinique,] Guatemala, [Persia,] Calabria, China, (Houan and Pekin,) Cape Good Hope, Sicily, Murcia, N. Hebrides, Philippines, Alps, Vesuvius, Tyrol, Coblentz, Moluccas.

1831. Sicily, Palermo, Aleppo, [England,] Piedmont, Calabria, Sicily, Odessa, Sicily, Wallachia, [Barbadoes,] Jamacai, Palermo, Peru, Switzerland, Chili, Island of Trinidad, Vesuvius, Hindostan.

1832. Vesuvius, Sicily, Parma, Irkutsk, [Caucasus,] [Nova Scotia,] Saxony, Etna, Urals, Chili, [England.]

Summary and Inferences.

From a close inspection of the above, it will be perceived that the localities of nearly all the earthquake disturbances for those periods can be found on or near great circles, which correspond either to some phase of the ecliptic, or which form secondaries to the ecliptic, especially on or near those phases and secondaries pointed out in my paper on Ter. Mag., published in the October number of this "Journal."

I have not intentionally omitted (although possibly a few inadvertently,) in copying from the Mallet Catalogue, any locality that would favor the opposite view of this generalization by being exceptional, and have indeed enclosed several places in brackets to denote that they did not conform to the law, when really, by extending the zone a little farther than 300 miles each side of the great circle, or by taking other phases of the ecliptic and their secondaries than the two pointed out as having the most intensity, probably all the localities now in brackets might be brought within the law.

If this, then, be a correct inference, namely, that earthquake and volcanic phenomena manifest themselves chiefly in great circles, forming respectively angles of $23\frac{1}{2}°$ with the equator and with the meridians, then it seems reasonable also to conclude that solar influence, in its reaction from within the earth upon the crust of the earth, was originally the cause of the variations we find on the earth's surface, and continues indirectly to be the cause of the existing volcanic phenomena.

This may be true, whether we adopt the theory of much or little liquid material below the earth's crust, and also whether we consider chemical action or some other cause the immediate dynamic agent in

generating the molten materials, gases, &c., which find vent at the craters. The high probability of the suggestions made in the first paper seem sustained by these observed phenomena: that difference in temperature along the ecliptic produces a current of electricity from east to west; that magnetism is thereby induced not only in all freely suspended or permanently laid steel bars and needles, causing them when free to rest at right angles to the plane of the globe-encircling electrical current, but also in all the iron in the earth not too much oxidized, and probably other materials; that this magnetism, by correlation, is converted into such heat and chemical action as is sufficient to produce the subterranean dynamics, usually accompaning seismic phenomena.

The subject is well worthy of attention, and develops an interesting field for further investigation and reflection.

LIGHTNING AND LIGHTNING RODS.

By David Brooks.

(A Paper read before the Meteorological Section of the Franklin Institute, July 1st, 1872.)

A plate of zinc immersed in water becomes feebly electrified with negative electricity. The presence of electricity is shown by the electroscope. A plate of copper in the same water is also electrified with positive electricity. This is the simplest form of a galvanic element.

With wires or conductors attached to these plates, connecting them to other metallic plates, separated by a non-conductor, the latter plates become much more sensibly charged with electricity by *induction*. This is called *accumulation*. Increasing the number of elements, the accumulation becomes greater in proportion to the number of elements used. When the plates of the *accumulator* are separated by a thin piece of paper, saturated with paraffin, and from one hundred to five hundred cells or elements are used, then the accumulation is sufficient to burst through the paper and produce, in a very minute degree, the phenomenon we call *lightning*. We have a very rapid succession of discharges and reports, somewhat resembling that of the breaking of threads in tearing a piece of muslin.

The discharge of the *condenser* or *accumulator* has its analogy in the thunder-storm, differing only in immense degree.

The accumulation in the plates of the condenser is proportional to the number of cells or tension of the battery—to the proximity of

the plates, and to their size or surface. To produce accumulation sufficient for disruptive discharge, they are separated only one-thousandth of an inch, because the other conditions are of small degree or insignificant proportions.

In the case of the thunder-storm, the cloud is one of the plates of the condenser, the air serves the purpose of the paraffined paper, and the earth is the other plate.

When a cloud passes over the earth it becomes charged with electricity, and the earth directly beneath the cloud is charged with the opposite electricity; but discharge or lightning depends upon the amount of electricity accumulated, the tension of this accumulation, and the proximity of this cloud to the earth.

The cloud is sometimes charged positively, sometimes negatively, but whatever the amount of this electricity, an equal amount of the opposite electricity is accumulated in the earth or some neighboring cloud, or the opposite electricity may be divided or distributed among other clouds and the earth.

It is conceded that clouds are always charged to a greater or lesser extent. The circumstances combining may be such that no violent disruptive discharge is produced. There may be but one discharge, and again there may be a hundred from the same cloud, all depending upon a variety of circumstances.

Again, the paraffined paper or dielectric does not at any time entirely prevent leakage, or the silent passage of the current from one plate to the other. This leakage may prevent sufficient accumulation to cause discharge or lightning; so the air conducts a given amount of electricity directly from the cloud to the earth. This alone will in time silently discharge the cloud and bring about neutralization.

Suppose we undertake to fill a standpipe with water, and this standpipe leaks at every pore, with a certain or given supply or head we can fill this pipe to a certain height.

The height of this pipe is indefinite, and it is desired to burst it. This can only be done by getting a sufficient height of water in the pipe. This height or head we will call *accumulation*. Now, to get sufficient accumulation to burst the pipe, we must have a certain supply, which we will call quantity. It must have a certain head or force, which we call *tension*, and it must not have too great a leakage. The leakage is, to a certain extent, in proportion to the tension; the greater the tension, the greater the leakage. We can, under given conditions, fill this pipe only to a given height; but to fill it higher,

or to the point of bursting, we must increase the quantity—increase the head or decrease the leakage. If the supply is lessened, the quantity accumulated is diminished. If the supply is stopped, the pipe is discharged in time by leakage, and this discharge is silent and unobserved.

The conditions requisite to the explosive discharge of the cloud are somewhat analogous to those necessary in the bursting of the standpipe, as above indicated.

In the accompanying cut A represents a charged cloud; E the earth; NP a conductor suspended midway between the earth and the cloud. We will call this conductor an iron rod. The effect of placing this rod between the earth and the cloud in the position shown, is to facilitate the discharge of the cloud to the earth. If the cloud is charged with positive electricity, the rod becomes polarized—that is, if the cloud is charged with positive electricity, the upper end of the rod is charged with negative, the bottom portion with positive, the opposite of the earth, which is negative. The effect of this rod is nearly the same, whether connected to the earth or insulated from the earth, as shown in the figure; but, being insulated, it endangers or makes liable to receive the discharge any other conducting bodies placed in positions of 1, 2 and 3—an ordinary discharge striking but one of these objects, say 1, which is most directly in its course to earth, a discharge of greater degree striking 1 and 2, a still greater one striking all of the objects.

Now the object of this article is to explain that a large proportion of the lightning rods in this country are so arranged and constructed as to endanger rather than protect objects at 1, 2 and 3, the purpose designed.

I do not say that a greater proportion of buildings *having* lightning rods are destroyed or injured than of those not having them, although those making careful observations do give that as a result of their statistics. I shall undertake to show that this difficulty *consists in the*

defective connection of these plates with the earth, and also that with a proper connection with the earth they are almost if not an absolute means of protection.

The rods extend into the earth, but the connection is so poor electrically—that is, the connection has so small conducting capacity—that accumulation takes place and violent discharge to any other neighboring object or conductor is the result, to very nearly the extent as if it were not touching the earth, as represented in the figure, and this difficulty consists in the imperfect nature of the joint or connection of the rod to the earth.

All objects conduct, but in vastly different degree. For instance, iron conducts only about one-sixth as well as copper. It has but one-sixth the conducting capacity. They conduct directly in proportion to their sectional area, and inversely in proportion to their length. A bar of copper that has one square inch section a foot in length, has the same conducting capacity of a bar of iron of six square inches section and a foot in length.

We will suppose it is desired to make a joint of these different metals, and that the joint shall have equal conductivity to any other section of these two conductors.

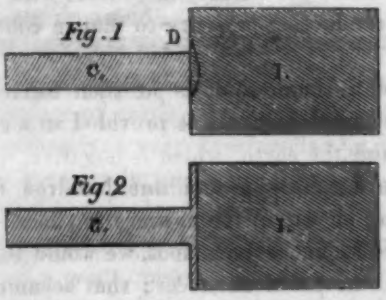


Fig. 1 represents a bar of copper, C, joined to a bar of iron, I, the portion of copper being one foot in length, and the iron the same, making a conductor two feet in length, the iron portion having six times the sectional area of the copper. This conductor will not have a conducting capacity equal to a bar two feet in length, all of which is of copper of equal section to the copper portion, or to a bar of iron two feet long, all of which has a section equal to the portion of iron, because there is a section of the iron in contact with the copper at D that has not the requisite sectional area; but if we were to enlarge the copper so as to bring the entire section of iron into the conducting circuit, as represented in Fig. 2, then this defect would be remedied, and such a conductor two feet in length, one foot of copper, the other of iron, would have a conducting capacity slightly in excess of a conductor of equal length, all of which is of iron or copper, because a portion of

the copper in contact with the iron has more than the given sectional area.

We must now draw upon the imagination to consider the difficulty in making a joint with a very poor conductor, viz., with water. We wish to make a joint between iron and water, the conducting capacity of iron being fully one thousand million times greater than water, and this joint is required to have equal conducting capacity to any section of the iron or lightning rod.

If the iron or lightning rod extended into water, and the section of iron were increased so as to equal ten square feet, the joint between these two conductors would have a conducting capacity infinitely below the section of any other portion of the iron conductor. We are in the habit of considering water as a conductor, but for this purpose it acts only as insulator, unless we can get its section comparatively in immense dimensions.

With any ordinary ground plate the lightning rod is insulated. Accumulation and explosive discharge is liable to occur.

We must now consider that instead of entering water, these ground plates usually are buried in earth, and that the earth conducts only as it contains moisture, and that in very damp earth the metallic plate should have at least four times the surface in contact with the earth, to make a joint of equal conducting capacity to that in contact with water alone.

The quantity and tension of a thunderbolt is of such immense degree, that unless an adequate channel or path is provided as a conductor, disastrous results are liable.

If the Mississippi river were a mile wide and one hundred feet deep, and this river was dammed, or cut off from shore to shore, except a single passage or aperture of one square foot, we would think there was an obstruction to the current of the river; that accumulation of water would certainly occur, and that some violent physical effect would be the result of this accumulation. But the capacity of this aperture, as compared to the size of the river, is no lessthan the capacity of an ordinary ground plate to conduct electricity, as compared to the capacity of an ordinary lightning rod to conduct the same.

A zinc plate three feet square, buried three feet deep in moist earth has a resistance of sixteen Siemens units. This plate was carefully laid in the yard of my factory. A stream of water runs on the surface of the ground directly over the plate.

A pound of copper drawn into No. 41 wire will extend in length about ten thousand yards. The diameter of this wire would be about

thirty-four ten thousandths of an inch, its resistance about half a Siemens unit per yard, or, in other words, a yard of this wire will conduct thirty-two times as much as this ground plate. Now, if we take out of a lightning rod one yard, and insert in its place a yard of this copper wire, which is of the diameter of a very fine human hair, we would naturally suppose this copper portion had not sufficient conducting capacity, yet it would obstruct the current only about one thirty-second part as much as the imperfect joint at the ground plate.

At the last meeting of this Section the defective nature of the joint of the rod to the earth was shown, owing to the insufficient conducting properties of water. The only method of obviating this difficulty is to enlarge the metallic surface of metal or rod coming in contact with the earth far more than is practised by the ordinary ground plate. I gave the conducting properties of water compared to iron as one to one thousand million. The ratio of difference is less in proportion as the water contains impurities ; but if the moisture in the earth were sulphuric acid and water, in the proportion of one of water to eleven of acid, the best conducting liquid known, the ratio of conductivity of this solution, compared to iron, would be, by the determination of Dr. Matthiessen, as one to one hundred and sixty-six thousand ; so that, making all due allowance for the impurity of the moisture on account of the acids and alkalies contained, the ground plate should expose a surface in damp earth at least equal to the surface of earth over which the building stands. Ordinary earth is specifically a very poor conductor, but owing to its immense size, is the best conductor known.

In Silliman's physics, p. 662, second edition, it is stated that : "In a church in New Haven the lightning has twice penetrated a 20-inch brick wall at a point opposite a gas pipe 20 feet above the earth, although the conductor of three-quarter inch iron was well mounted, but its connection with the earth was less perfect than that of the gas pipe." In this case, owing to the imperfect connection of the rod to earth, accumulation and explosive discharge took place. The gas pipe, owing to the great surface exposed in damp earth, was electrically a perfect connection to earth. Now suppose the rod to be cut at the point where discharge took place and fastened to the gas pipe, leaving the portion or stump of rod entering the earth to come within 20 inches of the rod now joined to the gas pipe and extending above the building. The stump of the rod would now occupy relatively the same distance, 20 inches, as did the pipe to the lightning rod, as stated.

The rod has a perfect connection to earth by means of the gas pipe. I do not think the lightning, if this rod was struck by every passing cloud from now to the end of time, would ever leave its course and fly to the stump.

The circumstance, as recorded in Silliman's Physics, is of common occurrence in this city. The lightning first takes to the rod which is imperfectly connected to the earth, and then leaves the rod in an explosive discharge to the gas or water pipes.

Now if the rods, instead of terminating in comparatively dry earth, were extended to the gas or water pipes and joined to them—say allow one yard of the rod to lay side by side with the pipe and bound together, by winding a wire round both—then a perfect connection to the earth would be made. This joint, if made to the gas pipe, had best be outside of the building. Then all danger is avoided.

In the country, where there are no gas or water pipes laid, the difficulty of making a proper connection to earth is serious. Unless a hundred square feet of metallic surface can be laid in the bed of a spring or body of water, I believe the building is safer without the lightning rod. It makes no difference whether the metallic plate is of copper or iron in point of conduction. Copper does not make moisture conduct, which is the difficulty we meet. Its only advantage over iron in this case is its durability.

There are many fallacies or vagaries prevailing in regard to the proper construction of the lightning rod, to which it is proper to briefly allude.

They are usually insulated with insulators at the fastenings. These insulators are generally glass thimbles, so placed as to prevent a metallic connection between the rod and the iron staple holding the rod in position. Now it is proposed to prevent a charge from reaching the staple, which can only be done by having a perfect connection to the earth. It makes an insecure fastening, and in no sense or contingency can it be shown to be of the least earthly use. In case the rod is imperfectly connected to the earth, the discharge would go through or over the glass, even if the glass had almost unlimited dimensions. By the use of the induction coil we can get up a charge that will perforate glass four inches thick. The force and intensity of a thunderbolt, we have every reason to believe, would as easily go through glass the thickness of a quarter of a mile.

The points are often tipped with gold, silver or platinum, to prevent them from becoming coated with rust, which conducts less perfectly

than the metal, and therefore acts as an insulator. Now if the point of the rod was made to enter the mouth of a glass bottle, the point of the rod would be millions of times better insulated than by a coating of rust, yet this covering of glass would comparatively be no obstacle in the way of a thunderbolt; so far as symmetry or appearance is concerned, the points are good, but their employment is of no practical account.

It is often supposed atmospheric electricity travels upon the surface of metals, and that a rod of iron flattened like a strap will conduct better than the same weight per foot in the shape of a round rod. An insulated metallic sphere when charged shows the electricity to be distributed on the outside surface, but this is owing to its nature to dissipate or diffuse from a common centre. There is nothing to show that it is not governed by the same laws as currents of less intensity, and that it flows in the channel offering least resistance in a proportion inversely as the resistance.

Church spires and towers, from their greater elevation, are most in danger of being struck by lightning. This has been noted from the earliest ages, but it is probable more property in the shape of barns is destroyed in the United States than all the rest taken collectively. This is owing to two causes: first, the combustible material they usually contain, and the comparative facility with which they are ignited; second, they are sometimes filled with hay and grain imperfectly cured or dried. These products ferment, or "heat," as the farmers term it, and the gas or steam rising from the mow of hay or grain affords a partial conductor for the discharge from the cloud, which it takes, and is led thereby into the barn. Many magnificent and valuable barns are destroyed with their contents annually in Pennsylvania from this cause. The year 1869 was unprecedented in Iowa for the continued rains during the harvest season. The grain was put up in stacks in a wet condition, fermentation took place, and the steam and gas arising being a partial conductor, hundreds of these stacks were destroyed by lightning.

In Illinois and Iowa more lives have been lost from the effects of lightning than in any other portion of the country—first, from the nature of the country, being level and devoid of trees, objects that attract lightning and protect in a measure, neighboring dwellings; second, the cabins of the early settlers were provided with stoves, the pipes of which projected through the roof and attracted the lightning, the effect of which often proved fatal to the occupants.

The annoying and disturbing effects of lightning upon the telegraph are chiefly inductive. A charged cloud often covers a space of a hundred square miles, extending over lines of telegraph. The points of greatest accumulation and disruptive discharge may be a distance of twenty miles from the wires. When the cloud extends over the wires a quantity of the electricity of the earth gathers upon the wires through the ground connections, and is discharged into the earth producing disturbance whenever discharge takes place, between the cloud and the earth, though the discharge or lightning may be twenty miles distant from the wires. We thus feel or observe upon the instruments the effects of these discharges inductively when we are too far from them to hear the report or see the flash. These inductive effects are often sufficient to melt the fine wire of the instruments, but not so severe as when the discharge is direct from the cloud to the wires.

It is by taking advantage of this principle of accumulation and discharge that the instruments are preserved from destruction by the lightning arrester. The instrument or relay is the resistance in the circuit which causes the accumulation, and this overcharge is made to pass between two plates or points and led to the earth.

I have been a very attentive observer of the effects of lightning upon buildings in this city for the past twenty years, and never yet known the occupants injured where gas or water pipes were used for the earth connection. The buildings are often set on fire by the lightning flying from lightning rods to the gas-pipes, or from metallic roofs to the gas-pipes. A person standing upon a metallic roof would be in great danger from this cause; but if the person is in the first or second story, and the gas-pipes extend to the third story, then the occupant is perfectly safe, unless there happened to be a defective lightning rod attached to the building, and the person were placed between the rod and gas-pipes at a point where they approached nearest each other. It is my firm belief that the manner of attaching rods to the earth, so defective as that ordinarily practiced, renders their use the cause of much more harm than benefit.

On page 89, fig. 66, of Noad's Text Book of Electricity, is illustrated a beautiful experiment of Sir Wm. Snow Harris, showing how the charge, in flying between two conductors, is deflected from the straight line, taking in its path smaller and detached conductors. The natural inference from this experiment is that there is no advantage in sharp points, nor disadvantage in having angles in the rod; also, that soldering the joints is not essential.

Metallic rods were used as early as the year 1800 to protect vessels from the effects of lightning, but with so little success they became very unpopular. The opinion prevailed for a period that they were the cause of more harm than benefit. Ships that had rods were often struck, sometimes causing great loss of life and damage. Snow Harris called the attention of the British Admiralty to their imperfect construction, and finally succeeded in introducing a system that was effectual. He connected the topmasts with the copper sheathing on the ship's bottom by copper straps running down the masts. He says, after a trial of this plan for twenty years, "in no instance has any ill consequence ensued," and "since the general introduction of this system into the public service, damage from lightning has vanished altogether from the navy."

In 1847 the honor of Knighthood was conferred upon Snow Harris, at the express command of her Majesty the Queen, "in consideration of his very useful inventions." It is also stated that he was recommended to the government as worthy of annuity of £300, "in consideration of services in the cultivation of science."

The copper sheathing of a ship's bottom coming in contact with the salt water would make electrically a perfect joint between the lightning-rod and the earth. The conducting properties of salt water of the ocean, exceed that of fresh water more than a hundred to one.

The true theory of the lightning-rod consists simply in furnishing a better conductor for the passage of the disruptive discharge than the objects we wish to protect; but it is of no avail whether made of large size iron or copper, unless it is electrically joined to the earth, in such manner as to provide ample passage for its harmless escape to the earth, otherwise the accumulated electricity will fly to other minor conductors producing evil consequences. The better the conductor without this essential connection, the more danger there is attending it.

Between two conductors well connected to the earth it takes to the better conductor of the two, and will, within certain limits, fly farther to the better conductor; or, in other words, a bar of iron one inch in diameter need not extend as high as a bar a half inch in diameter to receive the stroke, the two rods standing side by side, and other things equal.

In view of these principles, it is fallacious to suppose that a small iron rod, barely touching the ground, placed at a short distance from an oil tank made of iron, has any virtue to protect the tank which has thousands of times the attracting and conducting capacity of the rod itself.

Oil tanks are usually well connected to the earth, that is, electrically, by pipes running to the distilleries, and for the purposes of filling and discharging these tanks, the connecting pipes being buried in the ground. There have been explosions and fires involving great loss, connected with the manufacture and storage of petroleum, supposed to have originated by being struck by lightning. Do the lightning-rods we see placed so numerously about these tanks, have any effect to prevent these catastrophes? In my opinion not the least.

These tanks are immense air tight vessels, with the upper portion in the form of a dome. The lighter portions of these oils rise to the top of the dome. These lighter and more volatile oils are very inflammable, and when mixed with air are as explosive as gunpowder. The iron tank being electrically well connected to the earth, is a conductor exercising great attraction for the electricity of the clouds, and should a discharge from the cloud take place, the stroke would centre upon that portion of the dome most elevated, and directly upon the plate of iron in contact with the explosive compound. The iron becomes instantly melted or intensely heated, causing an explosion of the vessel, followed most probably by a frightful conflagration. This tank, which would upon first sight seem to be of a material most safe to protect the contents from fire or accident of this nature, is, upon reflection, exceedingly defective, and in imminent peril during times of thunder storms.

Magazines for the storage of gunpowder have been constructed in a very similar manner in the countries in the south of Europe, and although protected, or supposed to be protected by lightning rods, were really exploded by these very devices, involving, in some cases, fearful loss of life.

An iron rod fastened to the side or bottom of the tank, and made to extend say twenty or thirty feet above the dome, would be a part of the tank as a conductor. The point of the rod would be the point to receive the discharge. The lightning might melt an inch or so of the projecting point of the rod, but would not raise the temperature of any portion of the tank proper, or that in contact with the explosive or inflammable contents. Oil tanks could in this manner be safely protected from the effects of lightning.

It has generally been supposed that the water particles forming a cloud and held in free suspension, when charged with like electricities, repel each other. When discharge takes place these particles are left free to unite and form drops of rain, and in this manner we often

observe the drops of water reaching a very few seconds after the flash. But opposed to this theory is a too short space intervening, only a very few seconds of time, when the cloud is usually thousands of yards above. The drops would not have had time to come but a few hundred feet.

I would suggest a different explanation. The particles unite without discharge and neutralization; the drops form and begin to descend; when within a hundred feet, or very near the earth, these drops facilitate discharge, being minor and detached conductors, and polarized by being intermediate between the two great conductors, the cloud and the earth, so that when the drops have very nearly reached the earth, they facilitate the discharge in the same manner as the intermediate conductors in the experiment of Sir Wm. Snow Harris, referred to before. The drops may have been descending for one minute, but before actually reaching the earth they are anticipated by the flash or discharge.

Franklin Institute.

Proceedings of the Stated Meeting, March 21, 1872.

The meeting was called to order at the usual hour; in the absence of the President, Mr. Charles Close was called to the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their last meeting, held March 14th, 1872, donations to the Library had been reported from the following sources: The Governor-General of India, Memoirs of the Geological Survey; the Royal Astronomical, the Statistical, and the Royal Geographical Societies, of London, England; the Society of Arts; the Manchester Steam Users' Association, Manchester, England; United States Naval Department, Washington, papers on Eastern and Northern Extension of the Gulf Stream; State Geologist of Indiana, the Geological Survey of the State for 1869; On American Manures, by a member; John C. Trautwine, Esq., the Engineer's Pocket-Book; the Industrial Society of Muhlhouse, Germany; the Academy of Sciences of Paris, France, their Proceedings; and the Life of John J. Crittenden and Questions of the Day, from Geo. W. Childs, Esq., Philadelphia.

The Committee on the Rating of Steam Boilers reported progress